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Method for the digital and/or analog coding of information of one, two or more channels and/or frequency or bandwidth reduction and/or enhancement of the transmission reliability.

In this regard, frequency or time division multiplex combination of channels has been known heretofore. However, this necessitates great complexity and a large bandwidth. In the case of the invention, the serially arranged code elements are ordered individually in parallel and all of them together are combined to form a code word. Transmission reliability is achieved by the information being converted into PDM pulses and these pulses being recoded into the period durations of half-periods or period durations which are then transmitted in an uninterrupted sequence of positive and negative half-periods.

Method for the digital and/or analog coding of information of one, two or more channels and/or frequency or bandwidth reduction and/or enhancement of the transmission reliability.

The present invention is concerned with a method for the digital and/or analog coding of information of one, two or more channels and/or frequency or bandwidth reduction and/or enhancement of the transmission reliability.

For the transmission of information of a plurality of channels via one path, frequency and time division multiplex methods such as, e.g. the carrier frequency technique and pulse code modulation have been known heretofore. One disadvantage of these methods is that they require large bandwidths and great complexity.

The object of the present invention is to transmit the information of one, two or more channels with less bandwidth and to transmit the information of two or more channels via one channel with less bandwidth than would be necessary for the sum of the individual channels. This is done by the synchronously or quasi-synchronously arranged code elements of the different channels being ordered in parallel and all of them together being combined to form a code word and being transmitted. In addition, the intention is also to enhance the transmission reliability. This is done by the PAM pulses being converted into PDM, PPM and PFM pulses into sinusoidal half-periods or period pulses or code elements which are transmitted in an uninterrupted sequence of positive and negative half-periods. In this case, the half-period duration or period duration is a measure of the PDM-PPM and PFM pulses.

The invention can be employed, e.g. for combining telex, teletext, fax and digital telephone data

channels. The invention can advantageously be used in shared lines and line concentrators as well.

Furthermore, the invention exhibits possibilities for advantageously coding new television technologies for the improvement of C-MAC, D-MAC, D2-MAC, etc. Furthermore, it can also be used in the further development of the HDTV method. The possibilities for all these new television methods are highly restricted due to a bandwidth deficiency.

The invention is explained in more detail below with reference to drawings, in which:

Figure 1 illustrates the principle of a code division multiplex arrangement

Figure 2 illustrates the previous generation of phase jumps, e.g. in the case of 4 PSK

Figures 3 to 8 illustrate the generation of phase jumps

Figure 9 illustrates the generation of amplitude steps

Figures 10, 11 and 13 illustrate a representation of dual QAM and a vector diagram of higher-value coding

Figure 14 illustrates a vector diagram of dual QAM

Figure 16 illustrates the arrangement of the coding points in multi-value coding by means of amplitude magnitudes and phase angle

Figure 15 illustrates an overview of the generation of phase and amplitude steps

Figure 17 illustrates the generation of phase jumps

Figures 18, 19, 20, 21, 24, 28 illustrate code division multiplex examples

Figures 22, 23 illustrate an overview of a television transmitter and receiver

Figures 25, 26, 27 illustrate duplex traffic via lines and radio with just one alternating current with phase adjustment

Figure 29 illustrates the compensation of overlaps

Figures 30, 31, 32 illustrate the generation and conversion of PDM pulses into half-period pulses

Figures 33 to 38 illustrate the generation and conversion of PDM pulses into an alternating current

Figures 39 to 44 illustrate instances of coding in accordance with the invention for television

Figures 45, 46, 62, 63 illustrate a double binary and double duobinary arrangement of code elements

Figures 47, 48, 49 illustrate circuit overviews for television

Figures 50 to 55 illustrate instances of coding of colour television signals

Figures 56, 57, 58 illustrate the multiple utilization of transmission paths of PDM-coded signals

Figures 59, 60 illustrate the evaluation of phase-modulated signals

Figure 64 illustrates a graph showing the dependence of the frequency-modulated oscillation on the amplitude and frequency of the modulation oscillation.

A simple way of realizing phase jumps is described in Figures 3, 4, 5, 6 and 7. In the first instance, this will be explained in more detail with reference to Figure 3. Square-wave pulses having a frequency of 1 MHz are turned on at the transmitting end S. If, as illustrated in Figure 3c, a low-pass filter TP of 5.5 MHz is connected into the transmission path, what is almost still a square-wave pulse is obtained at the receiver E. If, as illustrated in Figure 3b, a low-pass filter TP of 3.5 MHz is connected in, the vertical edge steepness is no longer present; if, on the other hand, as

illustrated in Figure 3a, the low-pass filter is reduced to 1.5 MHz, then a sine-like alternating current having the period duration of the square-wave period is obtained at the receiver E. Thus, since the period duration does not change relative to the square-wave pulse, by altering the period durations of the square-wave pulses it is also possible to change the phase and/or frequency of the sinusoidal alternating current illustrated in Figure 3a. Since such a change always takes place at the zero crossing, a continuous change takes place and harmonics are hardly generated, that is to say the transmission is more narrowband than in the case of the phase keying systems that have been customary hitherto. At the receiving point, the change in the period duration can then also be provided as a measure of the phase jump. Such an evaluation circuit will be described later.

Figure 4 illustrates square-wave pulses with different period durations T = f, T = f1 and T = f2. After an analogous arrangement according to Figure 3a, a sinusoidal alternating current with the period durations T =1/f, T = 1/f1, T = 1/f2 would be obtained at the receiving end. Since the frequency of the alternating current decreases or increases in the event of phase jumps, the frequency change corresponds to a phase jump. This is clearly revealed by Figure 2, which illustrates conventional phase keying. It is evident from this that for each phase change a frequency change is effective, but not continuously. Therefore, it is also difficult to determine the size of the phase jump from the period duration at the receiving end.

In order to keep the frequency changes and thus also the frequency band small, each phase jump can be split into steps. Figure 5 depicts this diagrammatically. In Figure 5, T/2 is the half-period duration of a pulse and corresponds to 180 degrees. This angle is divided

into 36 steps each of 5 degrees. If a phase jump of 40 degrees is intended to be produced, then the half-period T/2 is shortened 4 times by 5 degrees, and of course so is the other half-period as well. The half-period duration relative to the reference pulse is then T1/2. After the phase jump, it is possible either to leave this frequency or else to change it over to the frequency T/2 again, by providing a phase jump of 5 degrees in the opposite direction. A phase shift of 30 degrees would then still be present relative to the reference phase. In Figure 6, the periods of the reference phase are illustrated 4 times with respect to time and the periods of the periods shortened by 2×5 degrees are illustrated 4 times. Upon comparison after the 4th period, the difference of 40 degrees relative to the reference phase is evident.

Figure 7 illustrates a circuit of an embodiment of the invention. It is assumed that the period duration is subdivided into 72 steps, to be precise with phase jump steps of 5 degrees. Each step is intended to be assigned 10 measurement pulses, and so 72×10 = 720 measurement pulses are necessary for the period duration and 360 measurement pulses are necessary for the half-period duration. Only the half-periods ever need be coded at the transmitting end. The 2nd half-period is then controlled in each case by means of the coder Cod. If phase jump steps of 5 degrees are provided, then 350 measurement pulses are necessary for the half-period, if the change is intended to be leading, and 370 measurement pulses are necessary in the case of a lagging phase change. The counting element Z in Figure 7 must therefore have at least 370 outputs. The measurement pulse frequency thus depends on the coding frequency. In the example of Figure 7, the control alternating current for the measurement pulses is generated in the oscillator

Osc. As a result, the counting element can be controlled directly via the gate G1, or, alternatively, pulses can be generated by means of a Schmitt trigger or another circuit and the counting element Z can then be switched by these pulses. The pulse duration can also be changed by altering the oscillator frequency. Assuming that the output Z2 at the counting element Z marks 370 measurement pulses, that is to say the lagging phase shift, then the coder Cod applies a potential via g2 to one input of the gate G2 which is such that, upon reaching the counting element output Z2, via which e.g. the same potential is then applied to the other input of G2, the potential at the output of G2 then changes, e.g. from h to l. In the electronic relay ER, this results in the positive potential + being applied to the output J. The coder Cod is connected to the electronic relay ER via the connection A. In the event of the next overflow of the counting element Z to Z2, ER is controlled via the connection A in such a way that negative potential - is applied to the output J. Bipolar square-wave pulses can thus be tapped off at the output of ER. Unipolar square-wave pulses could be generated in exactly the same way. This operation is repeated as long as the coder Cod applies potential to G2. If, by way of example, 5 phase steps are provided for a phase jump, then the counting element Z is switched 10 times to Z2. At the output Z2, the switch-back of the counting element is effected via the gate G4, R. Thus, by way of a differing number of outputs at the counting element Z and/or by altering the oscillator frequency, it is possible to set the pulse duration, the number of steps and the size of the steps. This variant is controlled by means of the coder Cod. The oscillator frequency can be changed over by way of fA, the number of steps and, if appropriate, the phase angle change and the step size by way of the terminals g2,

g3,.., and the amplitudes of the square-wave pulses J by way of A. Two sizes + (A) +, - (A) - are provided in the example. The square-wave pulses J are then connected to a low-pass filter in an analogous manner to Figure 3, and are passed via a transformer Ü, e.g. onto the transmission path, if appropriate with the interposition of a filter Fi.

Beginning potential must also be applied to the gate G1, via B, in order that the oscillator pulses take effect. The following instances of coding are thus possible with this arrangement: a leading phase shift, a lagging shift phase, no phase shift. These can also be effected in a step-by-step manner. The phase difference or the reference phase can be used. In addition, it is possible to provide amplitude coding, if appropriate in a step-by-step manner. A further possibility is to perform the coding upon the positive or negative pulse or half-cycle. The number of square-wave pulses is also a further code means.

It is also possible to filter out a harmonic of the square-wave pulses. If this is done, e.g. for the 3rd harmonic, then 3 periods are contained in a positive-negative pulse. The phase shifts are also contained in these 3 period durations when the pulse duration is altered.

In a wide variety of circuits, such as, e.g. in the case of quadrature amplitude modulation (QAM), alternating currents which are phase-shifted by 90 degrees with respect to one another are required. Figure 8 illustrates a circuit principle for generating such phase-shifted alternating currents of the same frequency. In an analogous manner to Figure 7, the counting element Z is controlled by an alternating current which is generated in the oscillator Osz and is passed via the gate G, at whose other input a beginning

potential B is present. In the example, the intention is to generate 4 square-wave pulses which are phase-shifted by 90 degrees with respect to one another. If the counting element Z has 100 outputs, then electronic relays ER1 to ER4 analogous to the ER relay in Figure 7 should be connected at the 25th, 50th, 75th and 100th outputs. Square-wave pulses are then generated by means of these electronic relays, as already described in Figure 7. In this case, the ER relays also contain means which always perform a potential reversal in the case of bipolar square-wave pulses and withdraw the potential during one sweep in the case of unipolar square-wave pulses. The square-wave pulses are then (designated by J in Figure 7) transmitted via the filters Fi1 to Fi4. The resultant alternating current has a phase shift of 90 degrees in each case relative to the current generated by the next output. Instead of phase-shifted alternating currents, pick-offs of e.g. PAM samples which are phase-shifted by 90 degrees can also be controlled by the outputs. A filter Fi0 is additionally arranged at the electronic relay ER1 and allows e.g. only the 3rd harmonic of the square-wave pulse to pass, with the result that the tripled frequency of the square-wave pulses is obtained here. The phase shift is then transferred to the 3rd harmonic.

With Figure 7, different amplitude steps can also be generated simultaneously. Only two are identified in the circuit. In Figure 9 there is a further possibility for generating different amplitude steps. The alternating current generated in Figure 7, for example, is fed to a limiter in which the control pulses are generated. The characteristic states are fed in via the terminal Code, which states perform a changeover to the amplitude magnitude determined by the code, to be precise in the coder Cod. The changeover to another amplitude

magnitude always takes place at the zero crossing. The magnitude of the amplitudes is determined by the resistors R1 to R4 arranged in AC circuits. Electronic relays I to Ives controlled by the coder Cod connect the various resistors into the AC circuits. Four amplitudes of different amplitudes are then obtained at the output A.

It is also known to code an information item by means of the half-cycles or periods of an alternating current; in the case of a binary code, the characteristic states are then a large and a small amplitude value. If 2 of such coding alternating currents of the same frequency are phase-shifted by 90 degrees and added, then they can be transmitted with an alternating current of the same frequency. Figures 10a,b illustrate the channels K1 and K2, which are coded by the periods as code elements with the characteristic states of large amplitude value = 1 and small amplitude value = 0. If one is phase-shifted by 90 degrees with respect to the other, then they can be added. Figure 11 illustrates their vector diagram. The channel K1 has the vector K1 (u) and the channel K2 has the vector k2 (v). The two characteristic states of the two alternating currents are designated by u1/uo and v1/vo. If both are then added, the 4 sum vectors I, IV and II, III are obtained. It can be seen that the vectors II and III no longer lie on the 45 degrees line. This makes the evaluation somewhat more difficult. Four possibilities which can all be placed on the 45 degrees line, designated by (II) and (III) in Figure 11, suffice for the evaluation of the binary signals. Figure 13 illustrates the 4 possibilities, 00, 11, 10, 01. If all 4 possibilities are on the 45 degrees vector, as illustrated in Figure 11, they can be coded by 4 amplitudes of different magnitudes, that is to say with a sinusoidal alternating current. Figure 9 illustrates

one such possibility. In order to transmit binary signals of two channels, therefore, a multi-value quaternary code is sufficient; such as e.g. 4 PSK or 4 QAM. These instances of coding are distributed between a period. In Figure 9, the positive and negative half-cycles are of the same magnitude; in that case, the transmission exhibits freedom from direct current. The positive and negative half-cycles can be utilized as an additional criterion. The 4 amplitude characteristic states can then be distributed, 2 to the positive half-cycle and 2 to the negative half-cycle. These may have the same magnitude, that is to say e.g. I + IV for the positive and negative half-cycles in Figure 11. To ensure that this coding alternating current always lies above the interference level, the coding alternating current must always have a specific magnitude, e.g. (III) as in Figure 11. The amplitude magnitude IV will than be increased somewhat.

Reduction of e.g. binary-coded alternating currents with the half-cycles or periods as code elements is already known. This presupposes phase shifts of the samples taken. The present invention demonstrates a further possibility for reducing the frequency of binary-coded information, in particular. Figure 1 depicts a channel K with a binary code 1,0,1,1.... If the frequency of the channel is intended to be reduced, into 2 channels at half the frequency, then in each case 2 serially arranged binary values of the channel K must be distributed in parallel between the channels Kv1 and Kv2; taking the example of the 4 values 1,0,1,1 of the channel K, the value 1 to Kv1, the value 0 to Kv2, the value 1 to Kv1 again and the other value 1 to Kv2. In this case, one value can always be stored, or the values can also be transmitted in a manner staggered over time. This must be taken into consideration during the evaluation. Simultaneous transmission of 2 channels has actually

already been explained in Figures 11 and 13. As is evident from Figure 13, 4 combinations are possible.

Figure 10 illustrates 4 coding alternating currents K1-K4 with the code elements of period and the characteristic states of large and small amplitude values of the same frequency. If there is a desire to transmit all 4 on the basis of QAM, they must have the following phases, K1 = 0 degrees, K2 = 90 degrees, K3 = 90 degrees and K4 = 180 degrees. K1/K2 and K3/K4 are combined to form a coding alternating current in accordance with Figure 9 and added. Figure 14 illustrates the vector diagram for this. It can be seen that 16 combinations are possible. Furthermore, it is evident from this that only 4 values lie on the 45 degrees vector. During the evaluation, the leading and lagging phase shifts must also be taken into account for the other values. The phase-shifted alternating currents are generated in an arrangement of the kind illustrated in Figure 8 and fed to 2 arrangements according to Figure 9, these alternating currents being phase-shifted by 90 degrees with respect to one another.

It is also possible to add an aggregate alternating current and single coding alternating current; a prerequisite is a phase shift of 90 degrees with respect to one another. Eight combination possibilities arise in this case.

Four channels can also be transmitted in coding division multiplex, as illustrated in Figure 1. In the first place, 16 combinations are necessary. Known instances of coding can also be provided for this, such as e.g. 16 PSK, 16 QAM and 8 PSK. Coding in this case requires one period in each case, if phase shifts in accordance with the present invention are provided. Instead of the characteristic states that are indeed in close proximity in the case of dual QAM according to

Figure 14, it is also possible to perform any desired coding. In Figure 16, the coding is performed by phase differences of 30 degrees and by 3 and 4 amplitude steps. If there is a desire for even greater reliability, the 4 amplitude steps BPh can be additionally divided. Steps may additionally be accommodated on the zero line. It is thus possible to provide each half-cycle for such coding. However, if there is a desire to perform transmission via wire-based transmission paths, it is expedient to transmit the negative half-cycle with the same coding, in order that freedom from direct current is manifested. A reduction can also be performed using the same method. In Figure 1, the channel is intended to be transmitted only at a quarter of the frequency. In each case 4 serially arranged binary elements 1 and 0 are arranged in parallel, as provided in Figures 1 a,b. The values 1,0, 1,1 of the channel K are then divided in parallel between the channel Kv1 "1", channel Kv2 "0", channel Kv3 "1" and channel Kv4 "1". In the coder, the predetermined coding point is then determined for the respective combination and transferred to the phase and amplitude of the coding alternating current. The phase is defined in Figure 7; if appropriate, it can also be used simultaneously to code the amplitude, and the required amplitudes can then be coded in Figure 9. The overview of this is illustrated in Figure 15. The coding point is defined on the basis of the four-element combination in the coder Cod. The phase coder generates the half-cycles or periods with corresponding phase and the amplitude coder generates the associated amplitudes. A phase coder may be embodied analogously to Figure 7 and an amplitude coder analogously to Figure 9.

A phase jump always signifies a change in the period duration. This change, that is to say frequency change, can be maintained if there is no further phase

change, or a changeover back to the original frequency can be effected during the next period or half-period. Since the alternating current has a different phase in the latter case, a reference phase is necessary during the evaluation. As emerges from Figure 4, with the aid of the circuit of Figure 7 it is possible to maintain any desired phase, that is to say maintain the frequency which was produced during the phase change. The phase changes are always performed at the zero crossing in the present case. In Figure 16, it is possible to provide a reference phase BPh, from which a phase shift is performed leading and lagging 2×30 degrees.

Figure 17 illustrates the generation of the phase jumps of Figure 16 according to the principle of Figure 7. The angle of 360 degrees is identified by 3600 pulses. If there is only an amplitude change with the reference phase, then the counting element is always switched through from 0 to 360 degrees. In this case, the control is effected by means of the coder Cod, which has already been described in Figure 7. In this case, the amplitude change is effected in the manner illustrated in Figure 7 or in Figure 9. If the phase jump Ph1 in Figure 16 is intended to be effected, then it is necessary, if freedom from direct current is required, for each half-period to be switched as far as the output 195. A reference phase is not necessary during the evaluation because, as long as no further phase change takes place, the unambiguous phase is, after all, defined by the period duration. If the coding lies on the vector Ph3, then the period duration is 330 degrees, that is to say a changeover is always effected at the output 165. In this case, the phase shift is always referred to the period duration. If, e.g. in the last case, the phase shift were referred to the half-period, then a switch-back would in each case have to be effected at the output

150. Other methods of generating phase jumps can be used in exactly the same way.

The phase jumps are evaluated in a known manner by measuring the period durations by means of an excessively increased control rate of counting elements, e.g. disclosed in European patent application 86104693.6.

A reference phase is necessary in the evaluation of Figure 14. The amplitude points 1 to 4 are arranged directly on the reference phase angle while the other 12 coding points are arranged such that they are leading and lagging with respect to the reference phase. It is assumed that the signals are those of a television system. In the blanking interval, the reference phase is then determined and, at the same time, control signals are transmitted. In this case, only the amplitude values on the reference phase are used. From the transmission path ÜW, the signals are fed to the input unit EST (Figure 12). They then pass to a limiter B, on the one hand, and to a code evaluation arrangement CA, on the other hand. In the limiter, the positive and negative half-cycles are converted into Jp and Jn pulses. In the comparison device VE, the phase of the pulses arriving from the transmission path is then compared with a reference phase pulse JBn. Figure 12a illustrates the leading, lagging and reference phase pulses Jv, Jn, JB which are compared with the reference phase pulse JBn determined from a coding. The 3 possible phase values of leading, lagging or reference phase are each passed to the code evaluation arrangement. In the latter, the amplitude values are determined and, in connection with the leading, lagging or reference phase, the coding points are then determined and forwarded via S for further utilization. The coding of the reference phase in the blanking interval may be configured e.g. in such a way that the point 2 is transmitted for 4 times and the

point 4 is transmitted 4 times on the reference phase. The evaluation thereof is carried out in the reference phase evaluation arrangement BA. The latter then passes a reference phase pulse JBn to the comparison device.

Figure 18 illustrates a further exemplary embodiment of the invention. The 5 channels K1 to K5 are intended to be transmitted by code division multiplex only via one channel or path. The e.g. binary-coded information of these 5 channels is firstly stored in the memory Sp. By way of example, Figure 20 illustrates the steps of the binary characters, to be precise in a manner such that they are already synchronized. Therefore, in each case 5 steps or pulses S1, 2, 3,... arranged in parallel are to be coded. The steps of S1 are 1-1-0-1-0. Five bits are necessary for the coding of these 32 combinations. In the example, these are coded with the amplitudes of the half-cycles of an alternating current with the characteristic states of large and small amplitude values and with a leading and a lagging phase jump of 36 degrees, as is shown in Figure 19. The binary values are fed to the coder Cod from the memory Sp of Figure 18 and are converted into a corresponding code in the said coder. In the decoder at the receiving end, the corresponding steps are assigned to the 5 channels again in accordance with the code.

Figure 21 illustrates a further application of the invention for the coding and transmission of the signals in colour television. The luminance signal is tapped off at 6 MHz. This principle has actually already been disclosed in the published patent application P 32 23 312. The colours red and blue are each intended to be tapped off at 1.2 MHz, that is to say one red and one blue tapping coincide with 5 luminance tappings. The luminance tappings are designated by I, II, III, IV, V. These samples taken are coded with 8 bits, binary-coded

in the example. With the tapping III, the tappings for red and blue must then also be carried out. The samples taken of red and blue are binary-coded with 6 bits in the example. During the transmission of the 5 luminance samples taken, the code for the red and blue colour samples taken is also simultaneously transmitted. With the tapping of red and blue, the transmission of the colour and the sampling I of the luminance signal could be begun. It is also possible to store all 5 luminance samples taken and colour signal samples and begin the transmission of all the television signals only after the 5th sampling. Figure 21a depicts the binary codes of all the signals to be transmitted. The 8 bits 1-8 of the luminance samples taken are each arranged in parallel. Then, serially, digital audio and other signals T + So, the 6 bits of the red signal and once again the audio and other signals are arranged under 9, 10, and the audio and other signals again and the 6 bits of the blue signal are arranged under 11, 12. It is expedient if the luminance samples I to V are still stored at the transmitter and the colour codes for red and blue are transmitted with the preceding luminance samples, so that it is then unnecessary for the 5 luminance samples to be stored at the receiver. Only the red and blue samples then need be stored. The audio and other signals must likewise be stored and then be fed to the loudspeaker contemporaneously with the picture. These signals can, of course, also be placed in the blanking interval. In the example, therefore, 12 bits are required for the transmission of a luminance sample for the audio and other signal samples and for the colour samples taken. Figure 21b illustrates an example of the coding of these 12 bits. Five half-periods of an alternating current are provided for this purpose. In this case, the binary code comprises code elements of the half-cycles with the

characteristic states of large and small amplitude values. In addition, a leading and lagging phase shift of 36 degrees is also provided, with the result that 12 bits are thus obtained.

Figure 22 illustrates an overview of such a television transmitter. The control element StO controls the television camera FK and also supplies the remaining control signals such blanking and synchronizing signals A + S. The red, green and blue signals are fed in the first place to the Y matrix YM and red and blue are simultaneously fed to the chrominance conditioning arrangement FA. At the same time, a concentrator K is provided, which taps off the luminance signal Y, the colour signals r + bl and the audio and other signals. At the tap 3, a criterion is passed via the connection 3a to the chrominance conditioning arrangement. In the latter, tapping off from the red and blue signals is performed and both values are stored in the capacitors C1 and C2. A Y value present at the 3rd tap is additionally fed to the FA by the Y matrix, with the result that the colour difference signals r-y and b-y are obtained at the taps 6a and 6b. - It is also possible to tap off just the colour separation signals. - By means of the module TSo, the audio and other signals are fed to the concentrator in an analogous manner via 6c and 6d. From the concentrator, all values are fed to a memory Sp. From the memory, the signals are fed in a correctly timed manner, e.g. as described in Figure 21a, to an analog/digital converter. In the latter, coding is effected in accordance with Figure 21b. During the blanking interval, a changeover is made to the concentrator K1 via U. As a blanking criterion, it is possible e.g. sometimes to transmit the code word with all zeros. --- In addition, other signals So can also be transmitted in the blanking interval. The beginning of a line can also be marked by

a zero code. Synchronization is predetermined during the line by the sequence and the number of half-cycles. In the case of the present code, a nominal frequency of 15 MHz is necessary. If there is a desire to use only one amplitude code, 2 alternating currents each at 18 MHz are necessary, which could then be phase-shifted by 90 degrees and added before being transmitted. It is merely a question of viability and reliability as to which method is used here. The leading or lagging phase jump is defined by the period duration in the example. Therefore, no reference phase is necessary in that case. It is possible, of course, to use multi-step amplitude codes and/or phase codes in order to reduce the frequency. The PAM signal, for example, can be applied to the audio input T, which signal is then tapped off occasionally within the 8 kHz time. In this case, there are numerous opportunities for utilizing the tap 6c/6d. Figure 23 illustrates a partial overview of a television receiver. The signals are fed to the demodulator DM via the RF oscillator and mixing stage and the amplifier V. In the said demodulator, e.g. the signals as illustrated in Figure 21b are obtained again and fed to the decoder DC. The colour signals are subsequently forwarded to the matrix Ma. The Y signal is also connected to the said matrix. By way of example, the colour difference signals R-Y, G-Y and B-Y are then obtained at the output of the matrix and, like UY, are passed to the television tube. The decoder DC then additionally supplies the blanking and synchronizing signals AS and the audio and other signals.

Figure 24 illustrates an example in which the code for the code division multiplex is obtained from a plurality of alternating currents. It represents a binary code in which the half-cycles of the alternating currents serve as code elements and in which a large and a small

amplitude value form the characteristic states. The characteristic identifiers to be transmitted comprise square-wave pulses at the frequency 1000 Hz, as is illustrated in Figure 24a. Twenty channels are intended to be transmitted in code division multiplex. The half-cycles of the alternating currents at 1000, 1500, 2000, 2500 and 3000 Hz are provided for this purpose. A plurality of channels at a lower bit frequency can, of course, be fed to each channel in time division multiplex. The same bit number could be achieved in exactly the same way with 2 alternating currents at 2000 Hz and once again 2 alternating currents at 3000 Hz, in which case these would each have to be phase-shifted by 90 degrees with respect to one another, so that they could be added in the event of transmission. The best way of producing synchronization between the individual channels is already known (Unterrichtsblätter der DBP Issue 4/6, 1979), and it will not, therefore, be discussed any further. Digitized voice or a plurality of voice channels can also be transmitted simultaneously in the same way.

In the case of amplitude coding, duplex operation can be carried out using the same alternating current. To that end, it is necessary for the remote coding alternating current to be phase-shifted by 90 degrees. Figure 25 illustrates this principle. In this case, the code may be digital, a binary code in accordance with the patent DE 30 10 938, or, alternatively, analog in accordance with Canadian patent 1 214 227. With half-cycles as code elements the frequency is 32 kHz in the case of digital coding and 4 kHz in the case of analog coding. In Figure 25, S1 is the microphone and E2 the receiver of one subscriber and S2 and E1 those of the other subscriber. In S1 there is also a coder in which the coding alternating current is

obtained from the speech. From S1, the coding alternating current passes via a hybrid G, the subscriber or connecting line RL to the hybrid G of the remote subscriber and to the receiver E1. The latter additionally contains a decoder which recovers the speech from the coding alternating current. The coding alternating current of S1 shall be the synchronizing alternating current. From E1, the said current is branched off via a 90 degrees phase shifter to S2, in which it is amplified, if appropriate. If S2 now speaks, a coding alternating current which is phase-shifted by 90 degrees is transmitted via G, RL, G to E2, where it is decoded and communicated to the receiver as speech. If, by way of example, simultaneous speaking occurs momentarily, an addition alternating current is produced on the transmission path RL. Cancellation is not caused. This principle can be provided in exactly the same way for duplex traffic in the case of data transmission. Further examples in this regard are disclosed in the published patent application DE 3802088.

This method can, of course, also be used for radio, e.g. for directional radio. Figure 26 depicts an overview in this regard. In this case, the transmission alternating current is concomitantly provided as the coding alternating current at the same time. Low-level modulation is advantageously used. The transmission alternating current is generated in the oscillator Osz1. The basic signal is converted into an alternating current digital code in the analog/digital converter A1/D1. It is even more simple if an arrangement according to Figure 7 is provided as oscillator and coder. From the coder, the electronic relay is then controlled in such a way that large and small square-wave pulses are present at the output J, and are then shaped to form a sinusoidal alternating current in the low-pass filter TP. The coding

alternating current then passes via amplifiers (not illustrated) to the output stage E and to the transmission antenna. A branch circuit may additionally be provided in the output stage, in which branch circuit the harmonics are phase-shifted by 180 degrees, and are then fed to the main circuit again for the purpose of compensation. At the receiving end, the useful signals are fed via a fixed tuning circuit to an amplifier V and then forwarded to the digital/analog converter D2/A2. The analog signal is then passed on, e.g. via a switching system. Via the amplifier V, the transmission alternating current is also branched off to a 90 degrees phase shifter Ph and then forwarded to the oscillator Osz2. The oscillator is synchronized with this. Via the converter A3/D3, amplifiers (not illustrated) and the output amplifier E, the transmitter of the opposite direction is then operated. The receiver E1 is connected in exactly the same way as the receiver E2, only the phase shifter is not necessary.

A phase shifter according to the principle of Figure 7 is illustrated in Figure 27. In the latter, compensation for small frequency fluctuations is provided at the same time. For this purpose, a counting element Z is provided which has 1000 outputs. During a half-cycle of the transmission alternating current, the counting element passes through these 1000 outputs. The control pulses Js are generated in an oscillator (not illustrated). In the case of a phase shift of 90 degrees, a phase shift of 45 degrees coincides with a half-cycle; that corresponds to 250 outputs. The transmission alternating current half-cycles coming from the amplifier V are fed to a limiter, with the result that square-wave pulses Jp and Jn are produced at the output thereof. These pulses are connected to the control element St. The control pulses Js and the beginning characteristic

identifier Be are additionally applied to the said control element. The control element is connected in such a way that only whole Jp and/or Jn pulses are ever activated at the counting element. If the counting element has reached the output 1000 during a pulse Jp, then the gate G11 assumes the operating position. A Jn pulse is connected to the gate G12 and, after the end of the Jp pulse, as a result of the delay of the monostable element mG4, potential is also momentarily connected to the said gate G12. G12 is activated and applies potential to one input of G13; I potential has already been applied to the other input of G13 from G11. A potential changeover then takes place at the output of G13 and inverts G16 at the output. The consequence of this is that G17 generates a switch-back potential for the counting element. Potential is also applied to the gates G8, G9 and G10 such that they, in interaction with the allocated outputs 1000, 999, 1001, control one of the monostable elements mG1, mG2 or mG3. Since the Jp pulse has controlled the counting element up to 1000, the gate G9 and mG2 has now been activated. If the counting element is then controlled to the output 250 by the next Jn pulse, then the gate G6 is activated, which controls the electronic relay ER which, in accordance with Figure 7, generates a square-wave pulse which is shaped to form a half-cycle in the low-pass filter. For the Jn pulse, the gates G15, G14 and the monostable element mG5 are arranged for the output marking. The monostable element mG2 is latched, e.g. up to the output 260. G6 then assumes the starting position again. The electronic relay remains in this position until the next marking of the output 250. If only the output 999 is reached due to a frequency fluctuation, then, instead of G9, the gate G8 is marked and mG1 and G5 are activated when the output 249 is reached. If the output 1001 is reached, then G10

and mG3 are activated, and the gate G7 is activated in the event of the output 251 being reached. Such frequency fluctuations are thus also passed on to the alternating current which is phase-shifted by 90 degrees. Figure 27a illustrates the control element in detail. The pulses Jn and also the beginning characteristic identifier are connected to the gate G3. If both are present, G3 is activated and causes the bistable element bG to attain the operating position, which then applies operating potential to the gate G1. It is only then that the Jp pulse can take effect. The control pulses Js then pass via the gate G2, which is merely a potential reversal gate, to the counting element. The further operations at the counting element have already been described.

In Figure 27, the negative half-cycle can be generated either by the Jn pulse, or the sweep of the positive half-cycle is repeated, the respectively marked outputs being stored.

The code used in the invention may preferably be an amplitude and/or phase code, of the kind illustrated by way of example in Figure 16. With purely an amplitude code, it is also possible to provide 2 code alternating currents of the same frequency, in which case one is then phase-shifted by 90 degrees in the event of transmission and subsequently added to the other.

The principle behind the invention can also be used for the transmission of digitized voice. Figure 28 illustrates 5 coding alternating currents with a binary code, the characteristic states being a large and a small amplitude value of the respective half-cycle. In this case, the frequencies are 8, 12, 16, 20 and 24 kHz. Twenty bits are obtained in this case; if 2 alternating currents of the same frequency, but phase-shifted by 90 degrees, are additionally provided, then 40 bits are obtained, that is to say, in the case of 8-bit code

words, as illustrated in Figure 28a, 5 digitized voice channels can thereby be transmitted.

In Figures 21 and 22, 2 audio tappings suffice per line given a tapping frequency of approximately 30 kHz (PAM) per line, which tappings can be effected e.g. at the beginning of the respective picture line and in the centre of the picture line; the spacing is then 32 µs. Each tapping is then converted into an 8-bit code in the analog/digital converter A/D and is then transmitted with the following 5 luminance code words, as is illustrated in Figure 21a. By way of example, with I/9, 1o, 11, 12 and V/9, 10, 11, 12 in Figure 21a. The tappings during the frame change time must be determined e.g. by time measurement. The coding is then also effected in the frame change time.

For the code division multiplex it is possible, of course, to use any desired code, such as the AMI or HDH-3 code. In the examples, an amplitude code is often used in which the code elements comprise the half-cycles or periods of a sinusoidal alternating current with the characteristic states of small and large amplitude values. In this case, one code element corresponds to one bit. If, by way of example, 12 bits are required for the CVBS and audio signals, then 12 half-cycles are necessary. The coding can be realized asynchronously with the tappings, since the length of the code words does not change. If, on the other hand, a phase code or additionally a phase code is provided, then the period duration also changes in the event of each phase change, with the result that, in the case of a periodic tapping and in the case of equidirectional phase changes, the signal tappings are no longer synchronous with the code. For compensation purposes, there are two possibilities in this case - in addition to buffer storage - in the first place re-establishing the nominal frequency in the event

of each phase change until the next phase change, e.g. in Figure 4 the nominal frequency f2 and, if a phase change T = f1 takes place and if the following codings have the same phase changes, then the following codings are coded with the nominal frequency f2. Only if the phase f1 changes again does a phase change then take place with regard to the reference phase, that is to say the reference phase must be stored at the receiver. The said reference phase can be transmitted by the transmitter, e.g. in the blanking interval. Another possibility for avoiding overlaps of 2 tappings consists in the following procedure: at the transmitter, with each code word, a measurement is made between the end of the code word and the preceding and the succeeding tapping. If there is the risk of an overlap in the leading or lagging direction, then code words having the smallest or largest period durations are interposed. Such code words are illustrated in Figures 29a and 29b. This can be circumvented by line storage.

In Figure 19, a code element has 6 different steps and the code word has 2 positions; consequently, 6 to the power of 2 combinations are possible, that is to say 36 combinations. Five bits are obtained with 32 combinations. In Figure 21b, a code element can likewise assume 6 steps, with the result that, given 5 positions, 6 to the power of 5 = 5184 combinations are possible, that is to say at least 12 bits. 4096 combinations are obtained with 12 bits.

In Figure 22, the PAM for the audio is generated in the TSO element and applied to 6c in each case, e.g. in a half-line by half-line manner. The terminals 6c and 6d are not necessary if the audio and the other signals are placed in the blanking interval, so that the concentrator K1 then performs these tasks.

The way in which e.g. the code division

multiplex can also be applied to television shall be shown with the aid of Figures 21, 22 and 23. The transmission frequency can, of course, be significantly reduced if more amplitudes and/or phase steps are provided. In addition, it is also possible to effect a combination with different carriers, as envisaged e.g. in the patent application P 32 29 139.6 Figure 9, or with different current paths. Thus, e.g. in Figure 28, a 64-kbit voice channel can be transmitted at 8 kHz, to be precise with a binary code. Two positions are each marked by the 2 half-cycles of an 8 kHz alternating current, and 2 further positions by the 2 half-cycles of an alternating current which is phase-shifted by 90 degrees. These 2 alternating currents are summed and transmitted as one alternating current via one current path. The same is carried out via a 2nd current path, so that the code word has 8 positions and 2 steps, with the result that 256 combinations are obtained. At the receiving end, decoding is performed after the evaluation of the half-cycles and, of course, buffer-storage. The coding can also be effected in a duobinary fashion.

A further method of transmitting, in a frequency-modulated manner, in particular analog signals such as voice, sounds, the luminance signal in television, the colour signals in television, telecontrol values, to be precise with less bandwidth, consists in converting the magnitude of the PAM pulses into PDM pulse lengths with the aid of pulse duration modulation PDM. These PDM pulses can then be converted into alternating current pulses, e.g. according to the method of Figure 7. The pulses are then formed by the half-cycles or periods of an alternating current, the period durations or half-period durations of the half-cycles or periods being equal to the length of the PDM pulses.

The spectrum of the frequency-modulated

oscillation used hitherto contains a large number of side oscillations above and below the carrier, which means that a very wide band is necessary in the case of transmission. In this case, the required bandwidth is greater than twice the frequency swing. In the case of the circuit according to the invention, predominantly digital switching means can be used, thereby enabling inexpensive production.

The method will now be explained in more detail below with reference to drawings. Firstly, known circuits will once again be explained, these being necessary inter alia in the context of generation (European patent application 0 284 019). Two exemplary embodiments of the invention are described below. Firstly, the principles behind the two embodiments are summarized. The information is in the first place subjected to pulse amplitude modulation and subsequently converted into pulse durations with the aid of the equidistance method, or else the information is directly coded into pulse durations with the aid of the sawtooth method. These pulse durations are then converted, in conjunction with the intervals between the pulse durations, into square-wave pulses and subsequently into sinusoidal coding alternating currents with the aid of filters. The pulse durations and intervals are converted with the aid of counting elements in conjunction with electronic switches. The pulse duration then corresponds to the duration of a half-period or period of the coding alternating current. If the pulse duration is short, the frequency of the half-cycle or period in the coding alternating current is high; if the pulse duration is long, then the frequency of the half-cycle or period in the coding alternating current is small. At the receiving end, the half-period or period durations are evaluated, for example by measurement. In this case, therefore,

frequency and phase modulation is simultaneously present.

In the case of the 2nd embodiment, the pulse duration pulse, PD1, PD2 in Figure 32, and the interval between the pulse durations (Figure 32, P) - the pulse duration and the interval each correspond e.g. to the interval between 2 tappings, designated by tp in Figure 30a - are fed to an electronic relay in which bipolar square-wave pulses are then generated. The frequency-modulated coding alternating current is then generated with the aid of filters.

Figure 7 illustrates how the time of a pulse is determined with the aid of a counting element Z in conjunction with the frequency of the stepping or measurement pulses generated in the oscillator Osc. The respective output of the counting element then marks the time. This is then provided in conjunction with gates for the control of an electronic relay ER. The latter then generates bipolar square-wave pulses.

The detailed functioning is as follows. The stepping or measurement pulses for the counting element Z are generated in the oscillator Osc. The said pulses pass via the gate G1 to the counting element Z as long as the beginning characteristic identifier is present at B. In the example, only the outputs Z1 and Z2 of the counting element are required. These outputs are connected to the gates G2 and G3. If the half-period of the square-wave pulse J is intended to have the magnitude of the sum of the measurement pulses up to Z1, h potential is applied to g3 from the coder Cod, with the result that a potential changeover takes place at the output of G3 when the output Z1 is reached, which potential changeover causes the electronic relay ER to end the square-wave pulse. If this was a positive pulse, then the next pulse will be negative. The counting element is then switched back again in this position. The

gate G4 is provided for this purpose at the output z2. From the coder, the oscillator frequency can also be increased or decreased via fA, with the result that, by way of example, different times could be marked by the respective outputs. A connection A also passes from the coder Cod to ER, and can be used to control different pulse magnitudes J.

The square-wave pulses are passed onto the line as a sinusoidal coding alternating current via a low-pass filter Tp, the transformer Ü and the filter Fi. The half-period or period of the coding alternating current is the same as that of the square-wave pulse. The principle behind the conversion of the square-wave pulses into a sinusoidal alternating current is illustrated in Figure 3. If, by way of example, square-wave pulses at the frequency 1 MHz are band-limited by a low-pass filter of 5.5 MHz, then rather steep edges are still obtained, as is illustrated in Figure 3c. A low-pass filter of 3.5 MHz was inserted in Figure 3b; it can be seen that the edge steepness has already diminished to a noticeable extent in this case. In Figure 3a, a low-pass filter of 1.5 MHz is connected in, and a sine-like alternating current is obtained at the receiver in this case. The period durations are identical to those of the square-wave pulses, that is to say that the period durations can be taken as a measure of the frequencies and/or phases. This principle was used in Figure 7 in the conversion of the square-wave pulses J into a coding alternating current with the aid of the low-pass filter TP.

Figure 4 depicts square-wave pulses having different period durations, to be precise expressed by the frequencies f, f1 and f2. These square-wave pulses have mutually different phase shifts and/or different frequencies. It can be seen from this that phase jumps and/or frequency jumps can be caused by changing the

period durations, so that frequency modulation is also obtained by this means. In Figure 5, such a phase and/or frequency jump is effected in a step-by-step manner. What is achieved as a result of this is that the bandwidth becomes small. As revealed by Figure 6, given phase jumps of 5 degrees per 180 degrees, a total phase shift of 40 degrees is obtained in the case of 4 phase jump steps.

Figure 30a illustrates PAM-coded pulses of a signal Inf. These pulses are converted into pulse duration pulses with the aid of an equidistant method, as is shown in Figure 30b. The distance between the PAM pulses (Figure 30a, tp) corresponds in each case to a pulse duration PD and an interval P, as illustrated in Figure 30b. Pulse duration modulation can also be carried out with the aid of the sawtooth method. This method is illustrated in Figures 31 and 32. The pulse durations are square-wave pulses PD1, PD2. Symmetrical PDM and bipolar PDM are also known (also see the book "Modulationsverfahren" [Modulation methods] by Stadler 1983).

Figure 35 illustrates an exemplary embodiment in accordance with the invention. In the pulse duration modulator PDM, the pulses are generated, e.g. according to Figure 30b or 32, and are passed via G5 to the gate G1. The measurement pulses Jm, e.g. at a frequency of 100 kHz, are present at the other input of the gate G1. As long as a PD pulse is present at G1, the measurement pulses Jm are activated at the output. The measurement pulses pass via the potential reversal gate G2 to the counting element Z, which is controlled by these pulses. The number of outputs at the counting element corresponds e.g. to the distance between two PAM pulses, tp in Figure 30a. Suppose that the tapping frequency is 10 kHz; the counting element would then have 100 000 outputs. The frequency swing is determined by the largest and smallest

amplitude values of the information item Inf, designated by gw and kw in Figure 30a. The outputs of the counting element Z lead to gates G3 and the outputs of the gates lead to gates G4. The respective PD pulse is present in each case at the other input of the gate G4, which pulse inhibits the gate G4. Only when the PD pulse is no longer there can the output potential also be activated at G4 via G3. ER then receives via G4 a potential changeover characteristic identifier for the next square-wave pulse. The beginning of the square-wave pulse is marked by the respective PD pulse. The next square-wave pulse is determined by the interval P (Figure 30b, P). From ER, a potential is applied to gate 5 via P, in order that the measurement pulses Jm become transmissive again at the gate G1. The counting element Z is then switched up to the output for gate G6. When the next PD pulse arrives again, G6 is activated and the counting element is switched back to the starting position via R. At the output of ER there are then square-wave pulses RJ having the magnitude of the half-periods like that of the PD pulses and of the intervals P. In the filter Fi, the square-wave pulses become sinusoidal half-cycles fmo, and so the information is frequency-modulated. The half-periods of the useful signal modulation frequencies then vary between the half-period durations identified by kw and gw at the counting element. In Figure 33, by way of example, kw = 15 kHz, the centre frequency is 10 kHz, and, in Figure 34, gw = 75 kHz. In the example, the pulse durations may change by half; this is a dimensioning matter of the pulse duration modulation circuits. The half-cycles of the intervals have a minimum frequency of 7.5 kHz in Figure 33 and a maximum frequency of 15 kHz in Figure 34. The amplitudes of the half-cycles always remain the same. The evaluation at the receiving end is effected by measuring the half-period durations.

Synchronization is not necessary since the zero crossings of a period simultaneously code the tappings in the case of coding with the aid of PAM; therefore, only the positive half-cycles need be converted into PAM pulses. The PAM pulses are then lagging by a period at the receiving end.

The redundancy of the intervals in Figure 35 can be avoided if, by way of example, the PAM pulses are stored and the next PAM pulse is called up after each PD coding. However, synchronization is then necessary at the receiver. If PAM were used at the transmitting end, the tapping frequency would have to be synchronized from time to time. Figure 36 illustrates the basic circuit of such a circuit at the transmitting end. The PAM pulses are stored in the memory Sp. The call-up of the next pulse arrives from ER via AR. In preparation, the next pulse had already been stored as PDM pulse in the memory Sp1. As a result, the counting element Z is then controlled by means of the control element St and set to a corresponding output. The counting element has also been returned to the starting position by ER via R. The control pulses Jm are also present at the control element. With the call-up of the PDM pulse, a PAM pulse is also passed from the memory Sp to the pulse duration modulator and is stored in the latter as a PDM pulse until the Sp1 memory is free again. Two Sp1 memories will expediently be provided and will then be connected to the control unit alternately after each call-up by ER. At the end of the PDM pulse, an end-of-criterion is passed to ER via the counting element Z, G1, G2. The square-wave pulse PD generated by ER is inverted to the next one, the counting element is switched back via R and, via AR, the call-up of the next [lacuna]

Figure 39 illustrates 4 channels with half-cycle coding with the characteristic states of large and

small amplitude values. The frequency is the same for all 4 channels. These 4 channels are provided for coding the colour television signals. Eight bits are provided for the Y signal (luminance signal), to be precise in each case 4 bits for the channels a and b; in each case 2 bits in the channels a and b are provided for audio and other signals T + S. The channel c is present for the coding of the red signal and the channel d is present for the coding of the blue signal, with 6 bits in each case. In each case 2 channels are then combined in accordance with Figure 11 vector I, (k1, k2) with the instances of coding I, (II), IV, (III), thereby resulting in an aggregate alternating current in accordance with Figure 9. The phase angle of the two aggregate alternating currents is then fixed at 0 degrees and 90 degrees. These 2 aggregate alternating currents can then be transmitted on the basis of quadrature amplitude modulation, with the result that a narrow band is required for transmitting all the colour television and other signals. Transmitted as dual QAM, that is to say channel a + b quadrature-amplitude-modulated and channels c + d quadrature-amplitude-modulated, where the channels have phase angles of 0°, 90°, 90° and 180° with respect to one another and their aggregate alternating currents have phase angles of 45° and 135°, and where the two aggregate alternating currents are again subjected to quadrature amplitude modulation, the evaluation is more difficult, as is also evident from Figure 11 (the vectors I, II and II are produced in the case of single QAM).

The 4 channels or their binary values can also be transmitted in code division multiplex. The binary values of the 4 channels are illustrated once again in Figure 40. In accordance with Figure 41, in each case 2 rows of Figure 40 are intended to be combined into 8 bits. In Figure 39, suppose that the frequency of the

alternating currents is 6 MHz; 18 MHz are then required for the coding. If, in Figure 41, use is made of duobinary coding in accordance with Figure 62 with the half-cycles as code elements, then although there would be a slight gain in bandwidth relative to Figure 39, the frequency would be 3 times as high. If the rows 1, 2, 3 and 4, 5, 6 are combined, that is to say 12 bits in each case, in this duobinary code, then a code word having 3 steps and 8 positions is necessary for one row 1, 2, 3. Eight positions mean 4 periods. A frequency of 2×24 MHz would thus be necessary, that is to say also too high for this purpose. Figure 45 illustrates a code element having 4 steps. With 4 steps, this results in 256 possibilities. Coding according to Figure 41 would result in a frequency reduction to 36 MHz. Figure 63 illustrates a code element having 6 steps. In order to serially code 3 rows of Figure 40, that is to say 12 bits, 5 positions would be necessary here. 30 MHz would thus still be necessary. In addition to the 3 amplitude steps, 2 phase steps or period durations are also provided. Figure 46 illustrates 3 amplitudes and 3 phase steps. If 2 rows each of 12 bits are formed from the arrangement of Figure 40, 3 positions are necessary for each row, that is to say 6 positions for both rows, in other words a frequency of 18 MHz is necessary.

The colour television signals are arranged differently in Figure 43. Eight bits for a Y tapping (luminance, pixel B) are serial each with 4 bits, and the colours red or blue are serial each with 3 bits in the rows III + IV. The respective 4th bit in rows 3 and 4 is provided for audio and other purposes. The colour red or blue respectively appears with every 2nd Y signal, that is to say these continually alternate. If the vertical rows 1/2 and 3/4, as illustrated in Figure 44, are combined, then more favourable conditions result in the

event of coding. With 4 steps, 3 positions are necessary; a frequency of 18 MHz is then necessary. If the rows 1/2 and 3/4 are arranged in parallel, that is to say 16 bits, then 4 positions, that is to say a frequency of 12 mHz, are necessary in the event of coding according to Figure 46. The dual QAM of Figure 39 can be transmitted in a frequency-modulated manner in order to provide even more reliability during transmission. The aggregate alternating current has only small frequency changes, with the result that, as revealed by Figure 64, the frequency-modulated oscillation can indeed be transmitted in a narrowband fashion. This figure reveals that the half-period duration T/2 becomes very short in the event of a frequency increase, in other words that the frequency greatly increases. With a modulation frequency Mf and an amplitude u, the half-period duration is T/2; with a doubled amplitude 2u, the half-period duration is shorter, while with the frequency doubled in addition, frequency M2f, the half-period duration is substantially reduced.

Figure 47 illustrates an overview of a television transmitter in which the codes explained in Figures 40, 41, 43 and 44 are used. From the multiplexer (not illustrated) the analog signals that have been tapped off arrive and pass into the analog memory ASp, from where the samples taken are forwarded to one or more analog/digital converters. The digitized signals are then stored in the digital memory DSp and subsequently fed to the ordering unit. In the latter, they are ordered in accordance with Figure 40, 41, 43 or 44. Having been ordered in this way, they are fed to the coder. They are coded in accordance with the predetermined code, e.g. according to Figure 45 or 46 or 62 or 63, and fed to the modulator MO. The transmission alternating current is fed to the modulator from the oscillator and the modulated

transmission alternating current is passed via amplifier stages (not illustrated) and the output amplifier to the antenna. An overview of the receiver for evaluating the coded signals is illustrated in Figure 48. A transmission alternating current arrives via the reception antenna E and passes into the stages tuning circuit/amplifier, mixing stage/oscillator Mi/Osc, via the intermediate frequency amplifier ZF to the demodulation stage - the input is connected like a superheterodyne receiver in the case of broadcasting reception -; the code alternating current is present at the output of the demodulator. The said current is connected into the decoder. The signals tapped off in the transmission multiplexer are obtained again here, such as the Y, r-y, b-y, audio and other signals S, and fed to the various circuits.

Figures 50 and 51 illustrate instances of analog coding of the colour television signals. An alternating current of the same frequency as the code alternating current is provided in Figure 50. The amplitudes of the half-cycles are the code elements. The tapping sequence is y, r, y, bl, y, T + S, etc. These analog-coded signals are transmitted on the basis of frequency modulation, with the result that a narrowband - only one frequency Figure 64 - and also transmission reliability are obtained.

An analog code is likewise provided in Figure 51. It is phase coding. The analog code is manifested by half-period durations of different lengths. In this case, the amplitudes of the half-cycles always have the same magnitude; it is a kind of frequency and phase modulation. The individual signals are arranged serially again, in the example y, r, y, bl, y, T + S. The transmission is effected at 6 MHz given a tapping frequency of the Y_ signal at 6 MHz. If multiplex tapping of all the signals is effected, that is to say including

the r, bl and T + S signals, then a tapping frequency of 12 MHz is necessary.

Coding in accordance with Figure 51 is provided in Figure 52, except that the audio and other signals T + S are coded by a superposed amplitude code. It is a binary code with a large and a small amplitude. The values of the Y and r + bl signals are defined by the half-period durations. In synchronism with the PDM pulse, the respective amplitude value is then passed e.g. to the ER relay of Figure 36, in which a square-wave pulse with a small or large voltage is then generated. The amplitude code elements may, for example, be assigned to a plurality of channels, such as audio stereo, etc. In Figure 55, the 4 half-cycle code elements are assigned to 4 different channels.

An evaluation of the PDM, PPM or PFM pulses with the half-period durations coded is evident from Figure 59. This is again effected with the aid of a sawtooth voltage. At the beginning of a half-cycle, that is to say at the zero crossing, the generator of the sawtooth voltage is switched on; after the half-cycle at the next zero crossing, the sawtooth voltage is momentarily connected to a capacitor, e.g. by means of a field-effect transistor, and stored in the said capacitor. The half-period duration T/2 is then identical to the voltage value T/2 or analogous to the magnitude of the voltage value. The half-period duration of 1 corresponds to the voltage value u1, that of 2 to that of u2, etc. If pulse amplitude modulation of speech at 8 kHz was effected at the transmitting end, then at the receiving end the voltage u1, u2, u3 must in each case be tapped off at the same frequency and converted into the speech alternating current. In the event of time division multiplex tapping of a plurality of channels, the stored values u1, u2, u3,... must be distributed again with the

same frequency of the time division multiplex tapping. The original information can be produced e.g. by the evaluated code u1, u2,... being formed in a staircase fashion after the channel allocation and this staircase signal being passed via a low-pass filter. Such conversions are known and will not, therefore, be discussed in any more detail.

In the same way as the PDM pulses in Figure 59, PPM pulses can also be decoded. This is illustrated in Figure 60. The distance T2 between the pulses is converted into PAM pulses again by the sawtooth method and stored. The distance T2 then corresponds to the voltage u1, etc.

In the case of the transmission of television signals according to the principle of Figures 36 and 38, the evaluated signals must be distributed synchronously at the receiving end. Synchronizing pulses have to be transmitted in the blanking interval in order that, in accordance with the sampling frequency at the transmitting end, the distribution frequency can be defined at the receiving end. The sum of the longest half-period durations that occur per line must not exceed the time of 54 µs. This is the time provided for a line in the case of a 4:3 picture format. Consequently, the half-period durations must be concomitantly measured in the transmitter. Under certain circumstances, a filling code e.g. comprising the minimum or maximum period durations in a specific sequence must additionally be inserted into the line code. It is also possible, of course, to provide other filling codes. Moreover, the blanking interval can additionally be provided as the filling code as well. Figure 61 illustrates the minimum and maximum half-period durations k and g. Such durations can be transmitted e.g. alternately. Based on this, it is also possible to combine a plurality of channels via one

transmission path. Figure 56 illustrates one such example. The multiplexer Mu combines the channels 1 to n in pulse amplitude terms, this actually being known. These PAM samples are stored in the memory Sp, called up by the PDM and, as already described, fed to the counting element via a control unit St, to which the control pulses Jm are connected. The remaining switching operations are the same as those described e.g. in Figure 36. After the pulse duration modulator PDM, the pulses can also be subjected to further processing directly in accordance with Figure 38. At the receiving end, of course, synchronization and distribution must be effected in accordance with the tapping frequency of the multiplexer.

Figure 57 demonstrates another possibility for multiple utilization of a current path. In order to be able to separate the code alternating currents in frequency terms, control pulses are used which are such that the frequency ranges of the code alternating currents are spaced apart such that entirely satisfactory evaluation is possible, e.g. separation at the receiving location by means of filters. In Figure 57, Z1 is one converter with the control pulses Jm1 and Z2 is the other converter or counting element with the control pulses Jm2. Figure 58 illustrates the frequency of the two channels. T/2I and T/2II are the smallest frequencies of the two channels. As a result of the angular swing f2, the frequency range of the channel T/2I is approximated more closely. In the example, a distance of Ab is also present. This can be chosen such that cost-effective filters can be used.

A few codes which can be used to code and transmit data, television signals in the example, with a frequency are also explained below. Figure 53 illustrates a binary code in which the amplitudes of half-cycles with

the characteristic states of large and small amplitude values are provided as code elements. One bit can then be coded with one half-cycle. Eight bits are provided for the Y signal, in each case 6 bits are provided for the red and blue signals, and 2 bits are provided for the audio (digitized) and other signals. Red and blue are coded alternately, as illustrated e.g. in Figure 51. In the case of 6 Meg tappings for the Y signal, a coding alternating current at 48 MHz would be necessary in this case. Duobinary coding is provided for this purpose in Figure 54. The coding alternating current then has a frequency of 27 MHz. These coding alternating currents can again be transmitted in a frequency-modulated manner; in this case, the frequency band does not become too wide either, as revealed by Figure 64. The transmission reliability becomes even greater in this case. Figure 66 depicts a possible way of digitally transmitting a message in a narrowband manner without modulators. Each code element is assigned a multiplicity of periods of an alternating current at a frequency which are determined by the time Og, that is to say a predetermined number of periods. It is assumed that binary coding is effected. Upon each state change, that is to say 1 to 0 or 0 to 1, the transition takes place continuously designated by Ü in Figure 66. The amplitudes for the zeros have the magnitude Ak and those for the 1s Ag. If identical values occur one after the other, then the amplitude magnitude is not changed; in the case of 5 identical values, a number of periods of 0g with the same amplitude would be obtained 5 times. The transition to another characteristic state is classed e.g. as the following characteristic state, that is to say e.g. Ü + O = Og. Figure 65 depicts how the television signals can be digitally arranged serially.

In Figures 53, 54 and 66, the frequency bands

for the transmission of the television signals are very narrow. Under certain circumstances, channels could be accommodated between the individual television channels. The carrier BTz is provided for this purpose in Figure 42. In the case of the coding according to Figure 66, the carrier is simultaneously the modulation signal. In the case of the modulation of the composite video signal with the intermediate frequency carrier 38.9 MHz, in addition to the filter for the generation of the vestigial sidebands, a tuned circuit or series resonant circuit is brought to a frequency such that a curve RR as illustrated in Figure 42 is produced. Such a series resonant circuit is easy to realize. The Nyquist slope should hardly be influenced by this measure.

Claims

1. Method for the digital and/or analog coding of information of one, two or more channels and/or frequency or bandwidth reduction and/or enhancement of the transmission reliability, characterized in that the transmission of information of one, two or a multiplicity of channels is effected with less bandwidth than is made up by the individual channel or the sum of the bandwidths of two or a multiplicity of channels, by the synchronously or quasi-synchronously arranged code elements of the channels to be transmitted being ordered in parallel (Figure 20, S1, S2,..) and thus being combined together to form a code word, and/or in that the digital or analog information items to be coded, if appropriate with the interposition of intermediate stages (e.g. PAM), are converted into PDM pulses, in that, furthermore, means are provided which convert the values of the PDM pulses into the half-period or period durations of half-cycles or periods of a sinusoidal or sine-like alternating current (Figure 35, ER, Figure 36, ER, Figure 38, ER).

2. Method for generating a frequency modulation, characterized in that means are provided which convert an information item or a signal (Figure 30a, Inf) into pulse durations (Figure 30b, 32), in that, furthermore, switching means for measuring the pulse durations, in particular counting switching means (Figure 35, Z), are provided, which simultaneously perform marking of the pulse durations (e.g. Figure 35, Z, A); in this case, the marking circuits are connected in conjunction with pulse duration pulses via gates to an electronic switching means (Figure 35, ER) in such a way that the start and the end of the respective pulse duration pulse code a periodic signal, in particular square-wave pulse;

furthermore, filter means are provided which are such that only sine-like or sinusoidal alternating currents and/or harmonics thereof reach the line (Figure 35, fmo).

3. Method for generating a frequency modulation, characterized in that means are provided which convert an information item or a signal into pulse durations, and in that, furthermore, switching means are provided which convert the duration pulses into an uninterrupted sequence (Pd, Pd, Pd,..) or which convert the pulse duration pulses and the associated intervals (Figure 32, PD1, P, PD2) into, in particular, square-wave pulses (Figures 36, 38), and in that filter means are subsequently provided which are such that they convert these into sinusoidal or sine-like half-cycles or periods to form a coding alternating current.

4. Method according to Claims 1 to 3, characterized in that the pulse duration pulses and intervals or, in the case of storage, pulse duration pulses in an uninterrupted sequence control electronic switching means directly (ER, Figures 36, 38) in such a way that the respective pulse duration or pulse duration interval is converted into a period duration or half-period duration of unipolar or bipolar square-wave pulses, and in that filter means are provided which turn the square-wave pulses into sine-like half-cycles or periods in an uninterrupted sequence of positive and negative half-cycles.

5. Method for evaluating distances e.g. between pulses or half-period or period durations, characterized in that, at the start of the distance marking (Figure 60, 1) or at the zero crossing of the half-period, means for generating a sawtooth voltage are started, and in that, at the end of the distance marking or at the 2nd zero crossing of the half-period (Figure 59), means are connected to the sawtooth voltage which form measurements

thereof or in that means are provided (FET) which store this voltage in a capacitor, in particular.

6. Method according to Claims 1 to 5, characterized in that multiple utilization of current paths is effected by a plurality of information channels being combined in time division multiplex (Figure 56) or by the control pulses for the counting elements obtaining (Figure 57, Jm1, Jm2) a frequency such that their coding alternating currents are not imparted any overlap during the transmission via a current path.

7. Method according to Claim 1, characterized in that, for the coding, a multi-step amplitude code (binary, duobinary, etc.) and/or a phase code or multi-step phase code and/or an analog amplitude and/or phase code is provided, which is provided in particular for the multiple utilization or reduction of the frequency in the case of telex (Figures 18, 19, 20), in the case of television (Figure 21), in the case of teletext, data transmission (Figure 24) and in the case of digital voice transmission (Figure 28).

8. Method for colour television, characterized in that, at the transmitting end, all of the signals are combined in code division multiplex, where the colour, audio and other signals can be assigned as required to a plurality of Y signals in code division multiplex, and in that the receiving end is designed like a superheterodyne receiver, the decoder being arranged downstream of the demodulator (Figure 23, DM), and the decoded signals being distributed in a correctly timed manner by means of the said decoder.

9. Method for the coding of the colour television signals, characterized in that the y signal, red signal y signal, blue signal, Y signal, audio + other signals are tapped off serially in an uninterrupted sequence, in that the PAM values are transferred to the half-period or

period duration of half-cycles or periods of an alternating current, to be precise in the event of amplitude identity, or in that only the sequence Y, r, Y, bl is provided and the audio and other signals are coded by a binary or duobinaryfrequency amplitude code (Figure 55) by each half-cycle or period being assigned an amplitude value which corresponds to the code, in which case the 4 amplitude values (Figure 52) can be assigned to different channels in code division multiplex.

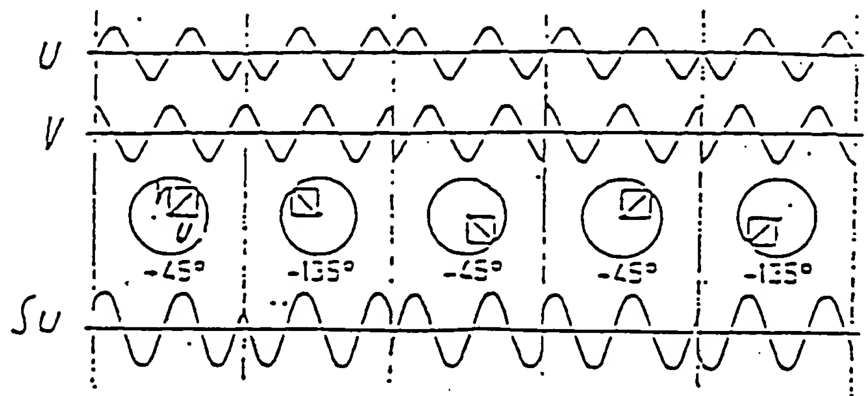
10. Method for the coding of the colour television signals, characterized in that the television signals are only coded with a frequency (Figures 53, 54, 66) by the serially arranged code elements formed by the amplitudes of the half-cycles or periods with the characteristic values of large or small amplitude value or small, medium and large amplitude value being provided for all of the signals, or in that the code is formed from a multiplicity of periods with 2 or 3 characteristic quantities and a continuous transition between the quantities (Figure 66, Ü), this code being provided, as required, for accommodating a channel in the gap between the conventional channels (Figure 42).

11. Method according to Claims 1, 7, 9 and 10, characterized in that the evaluation at the receiving end is effected as far as the decoder as in the case of a superheterodyne receiver.

12. Method according to Claims 1, 7, 8 to 11, characterized in that the television signals are transmitted on the basis of dual QAM, where the y signal is distributed between 2 channels each with 4 bits and these channels are additionally assigned in each case 2 bits for audio and other purposes, the code elements are the half-cycles of an alternating current with the characteristic states of large and small or large, medium and small amplitude values, and the transmission is

effected, as required, on the basis of frequency modulation.

Fig. 2



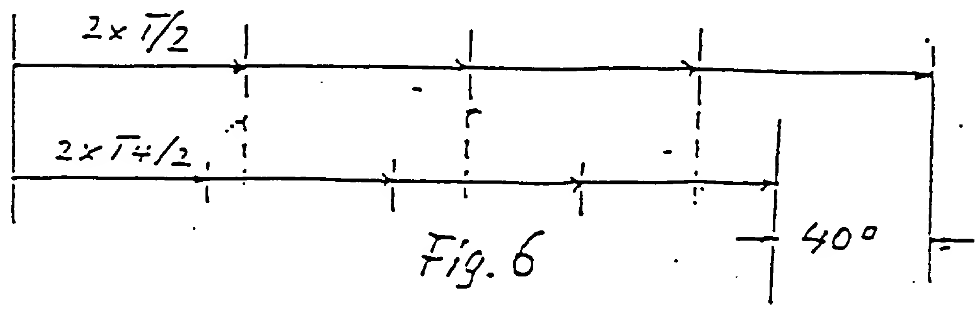


Fig. 6

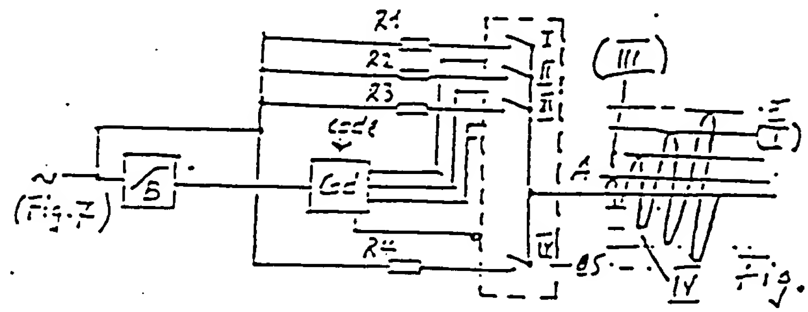


Fig. 9

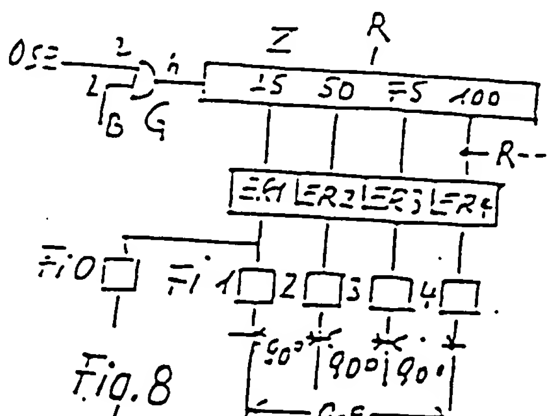


Fig. 8

Fig.10

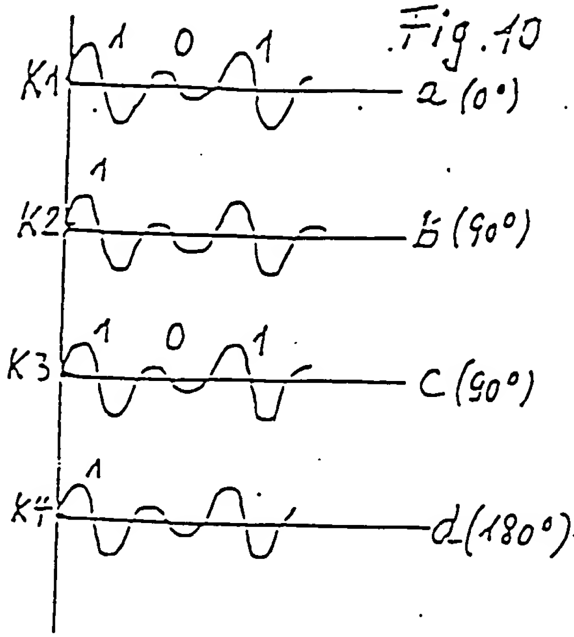


Fig.11

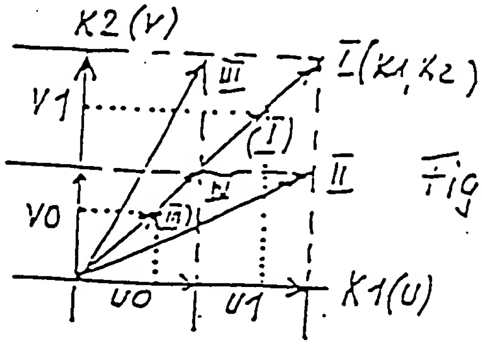


Fig.13

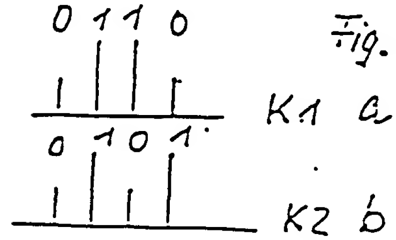


Fig.1:

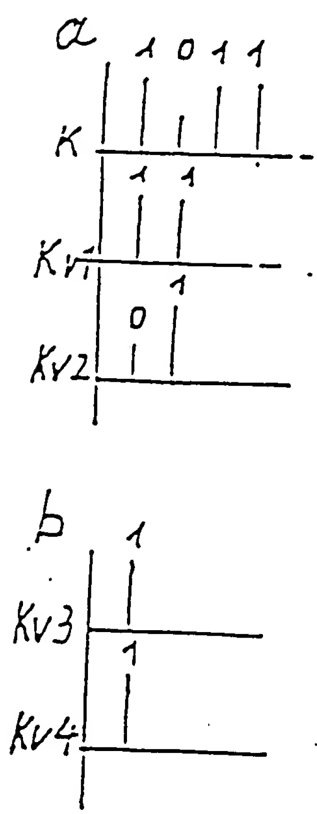


Fig.31a

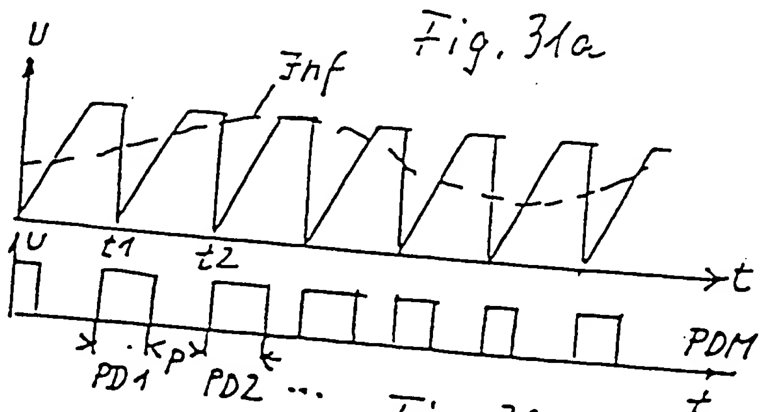


Fig.32a

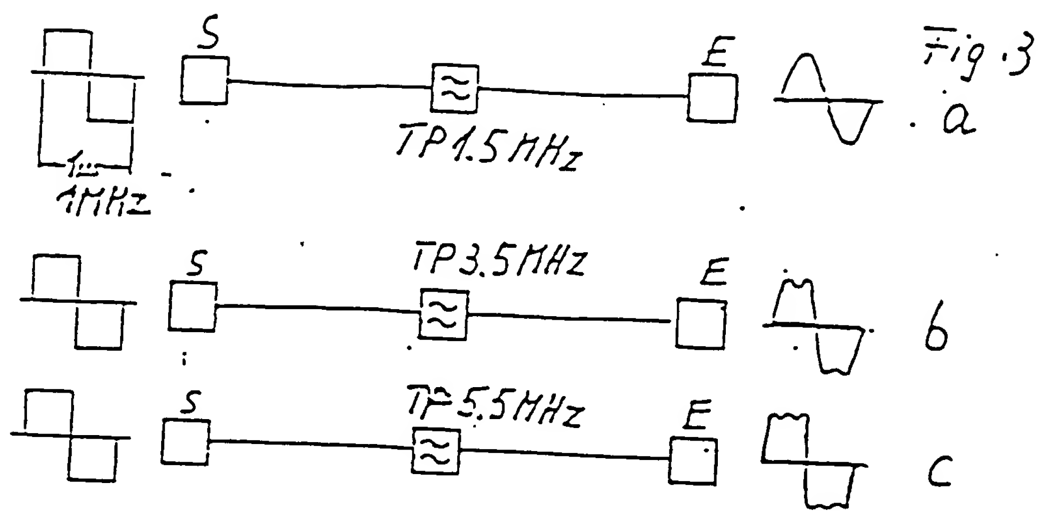
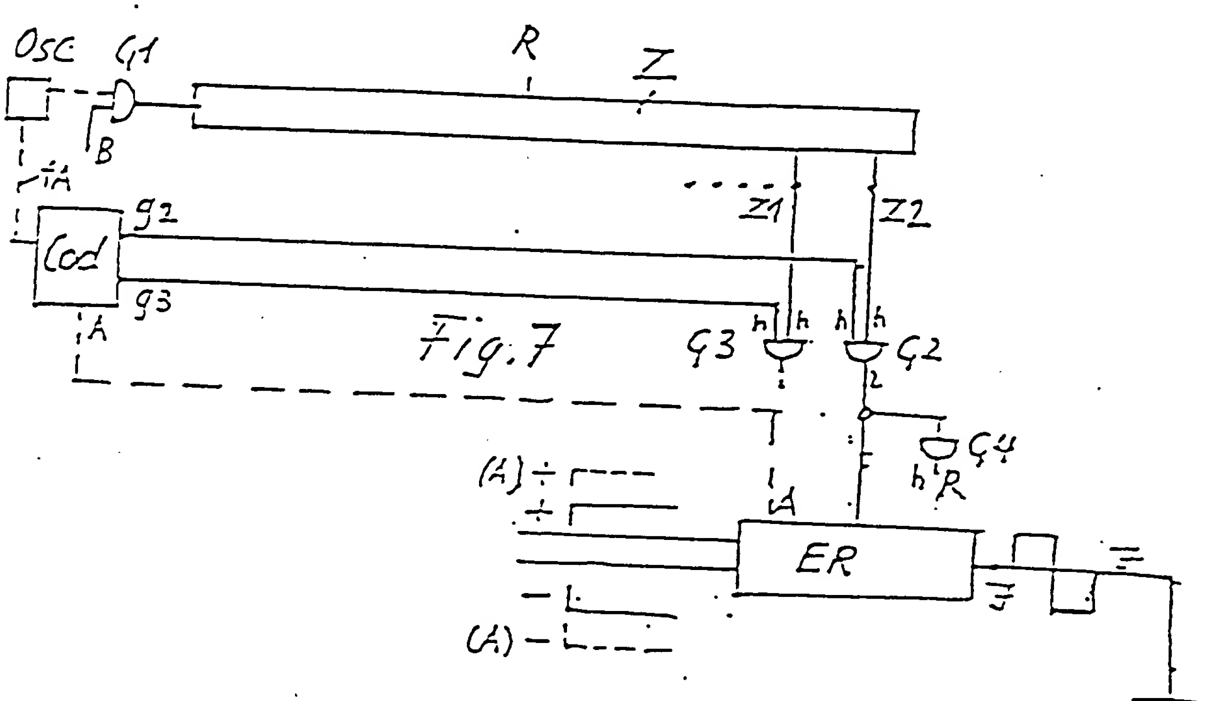


Fig.3



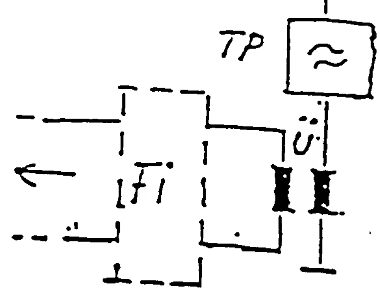


Fig.7

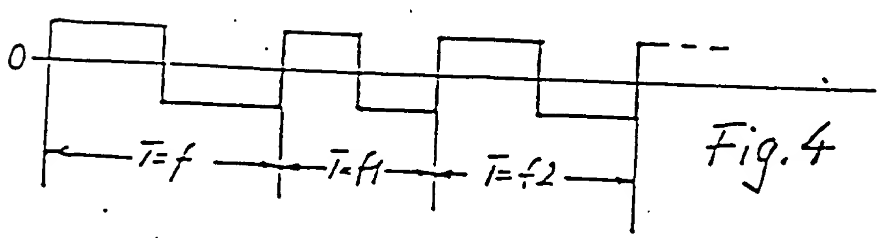


Fig.4

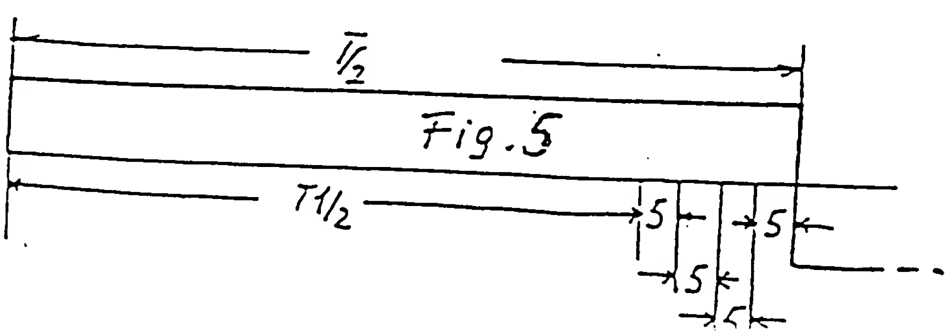


Fig.5

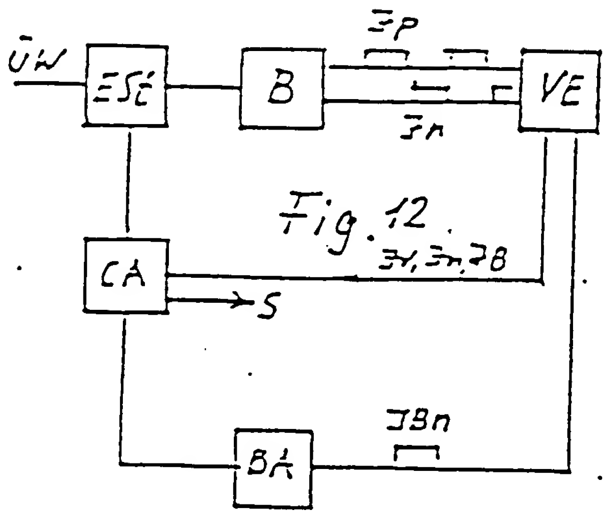


Fig. 12

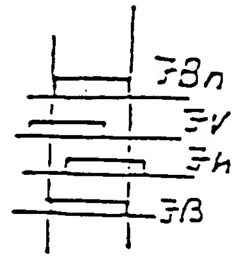


Fig. 12a

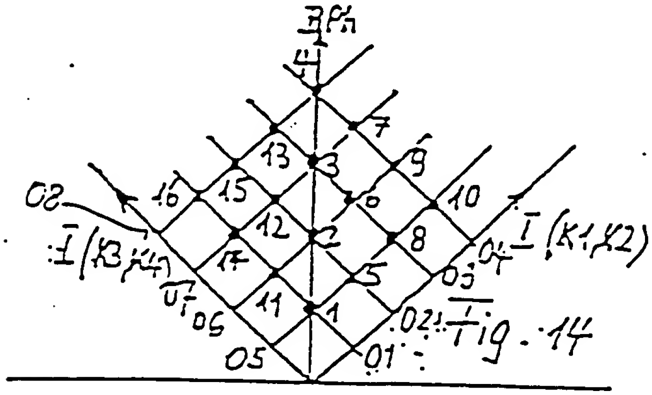


Fig. 14

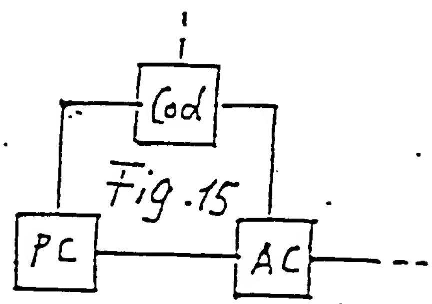


Fig. 15

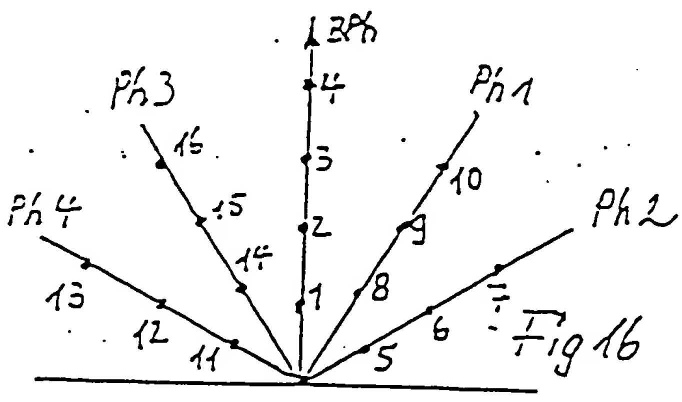


Fig 16

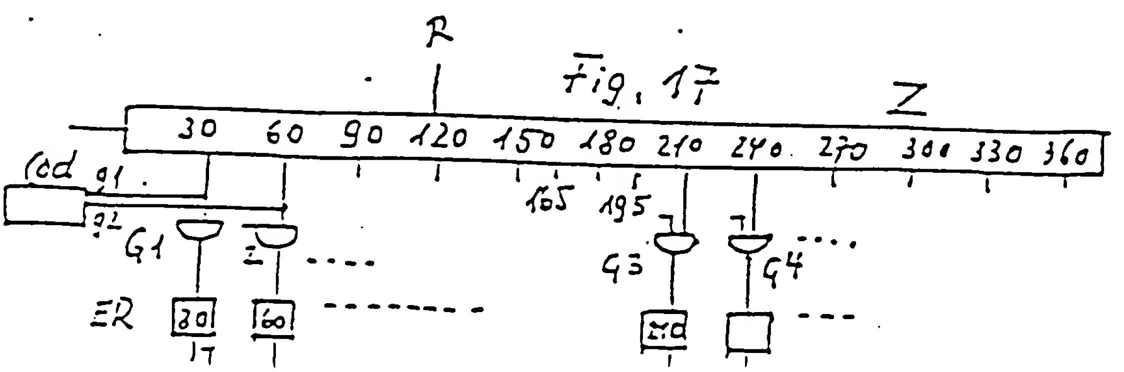


Fig. 17

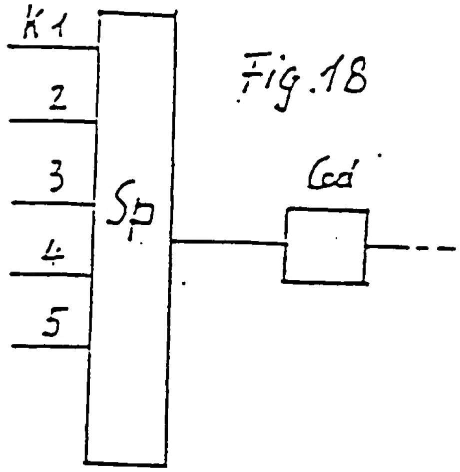


Fig. 18

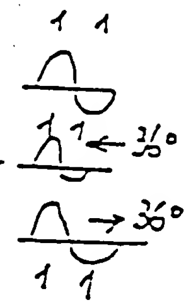
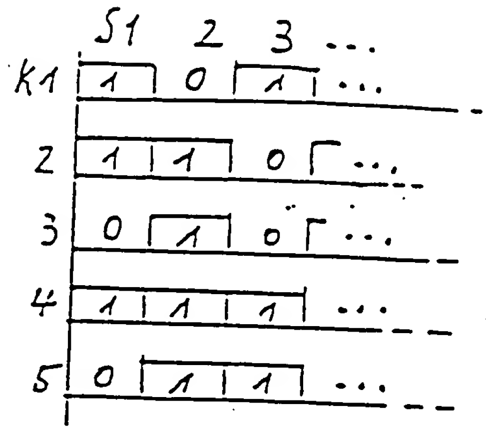


Fig. 19

Fig. 20



S1 = 1-1-0-1-0

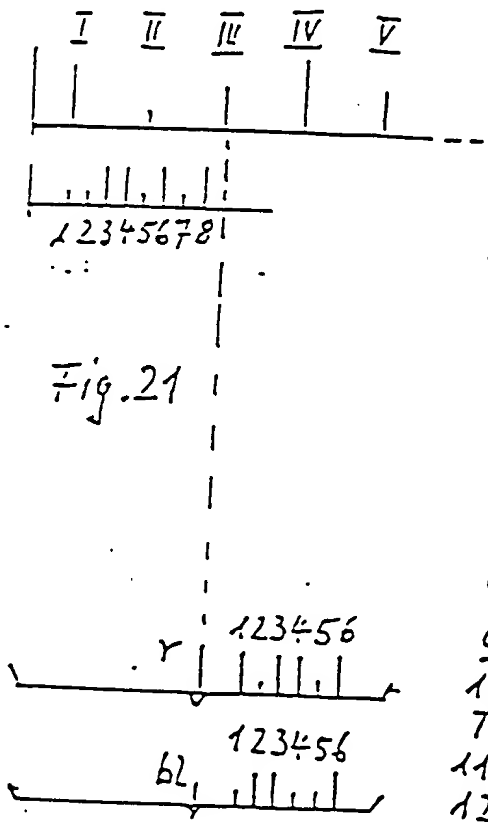
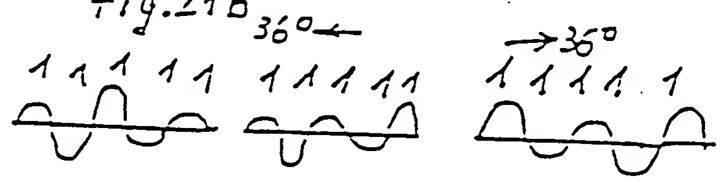


Fig. 21

Fig. 21b



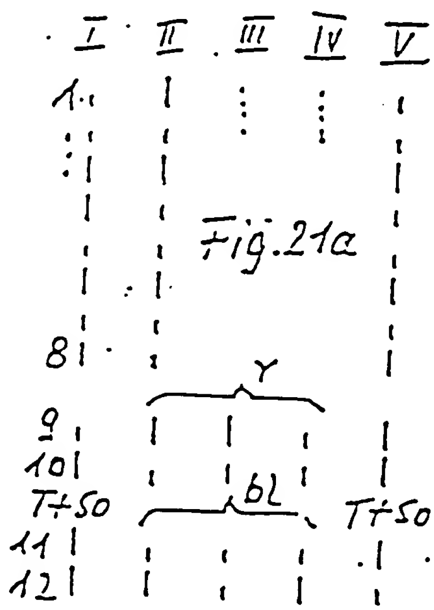


Fig. 21a

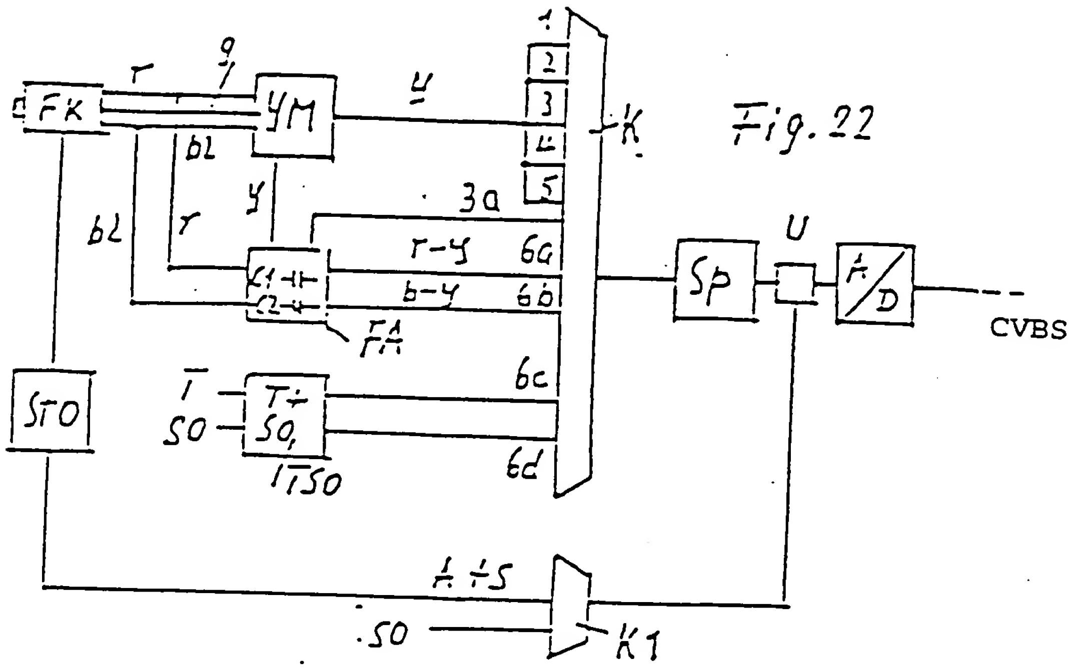


Fig. 22

Fig. 23

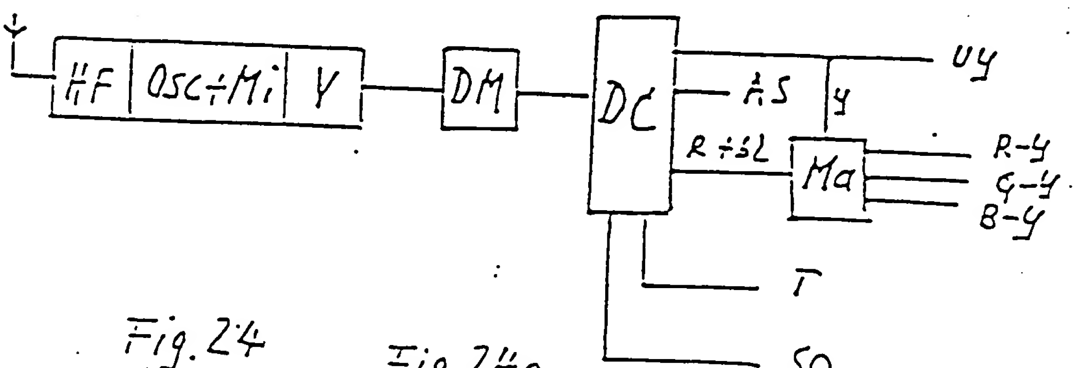


Fig. 24

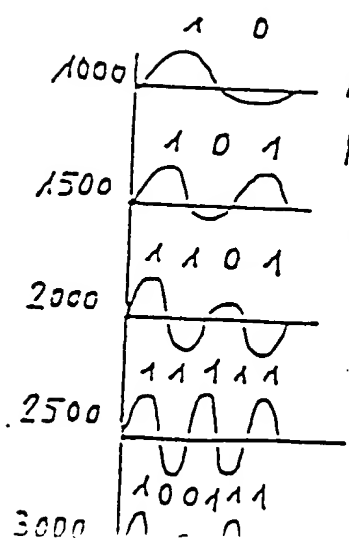


Fig. 24a

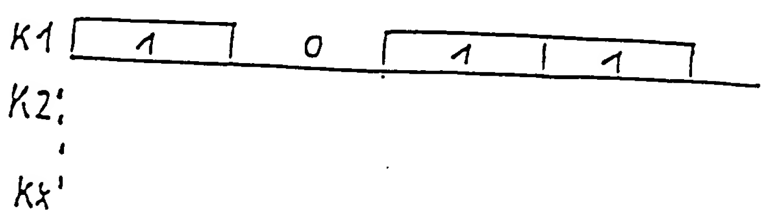


Fig. 29a

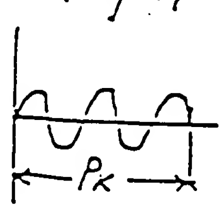
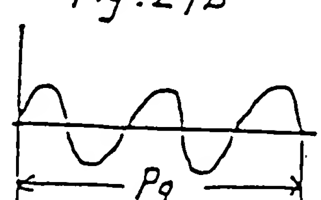


Fig. 29b



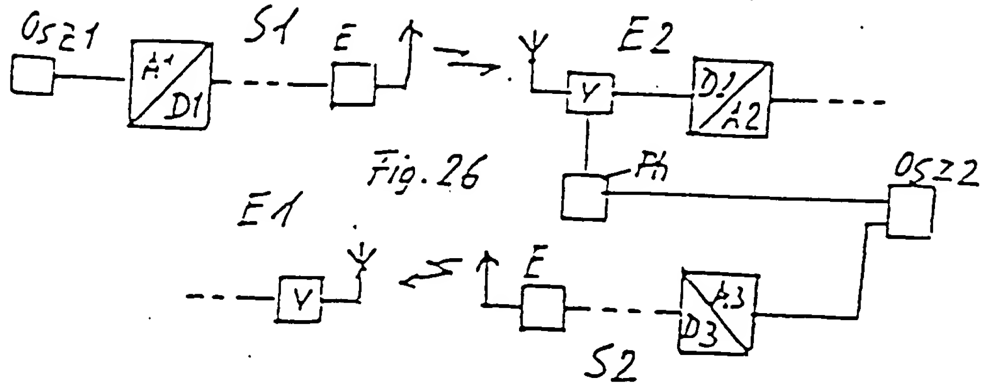
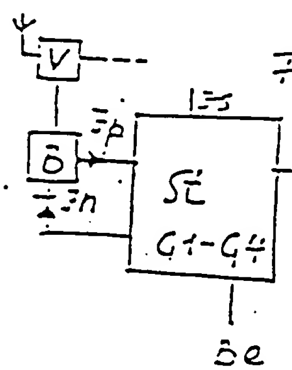


Fig. 26



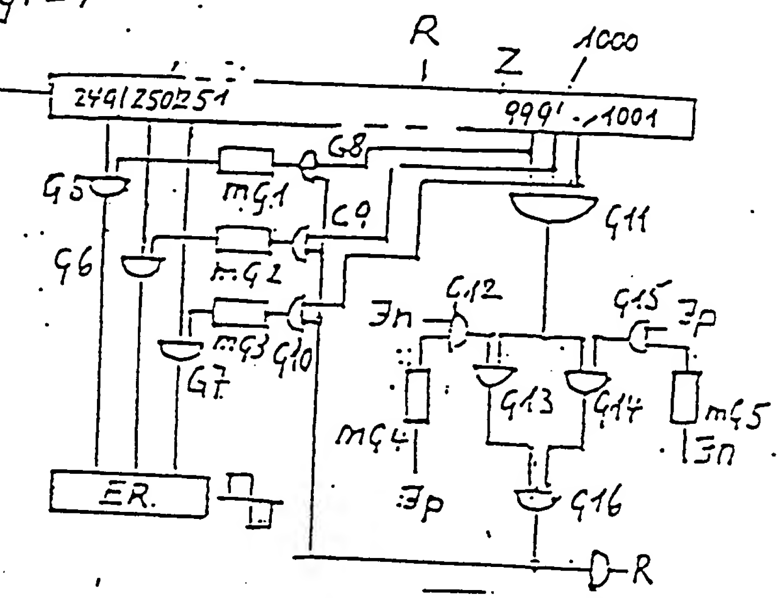


Fig. 27

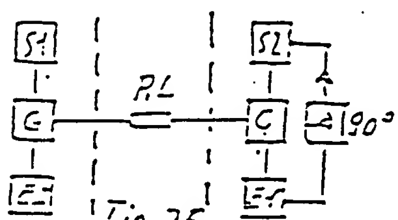


Fig. 25

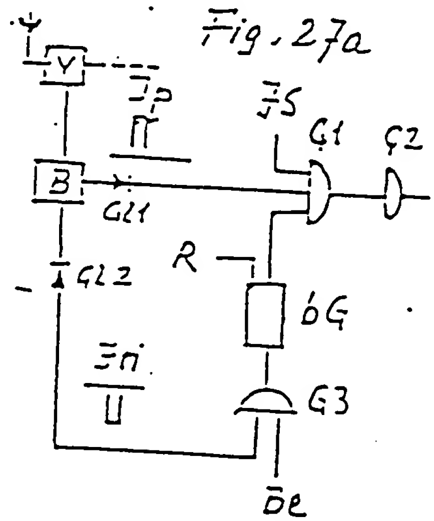
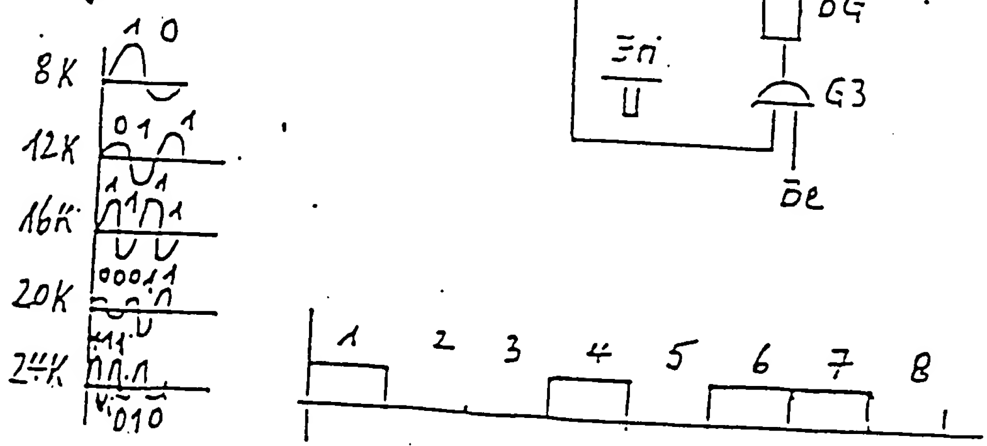


Fig. 27a

Fig. 28



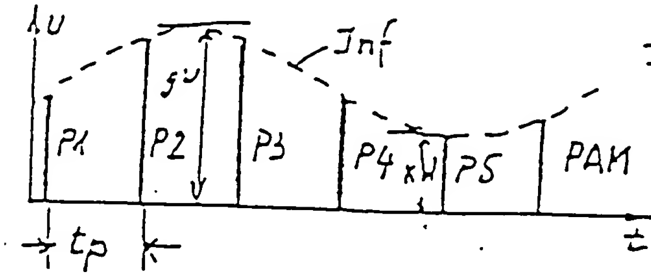


Fig. 30a

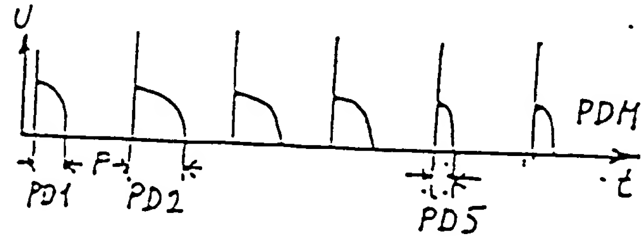


Fig. 30b

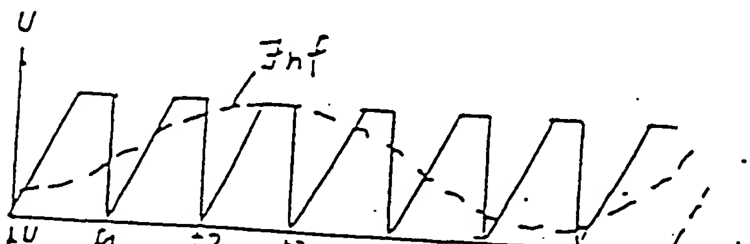
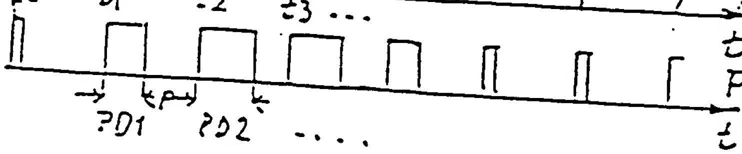


Fig. 31



PDM Fig. 32

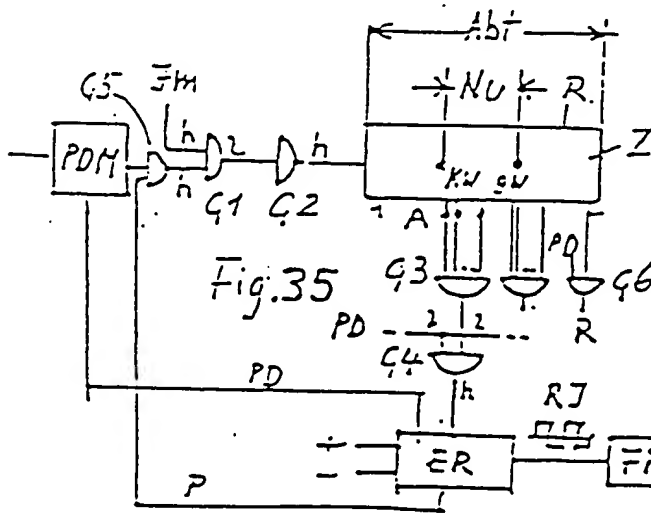


Fig. 35

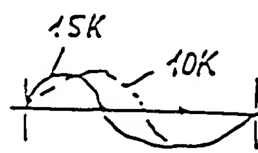


Fig. 33

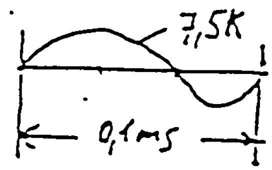


Fig. 34

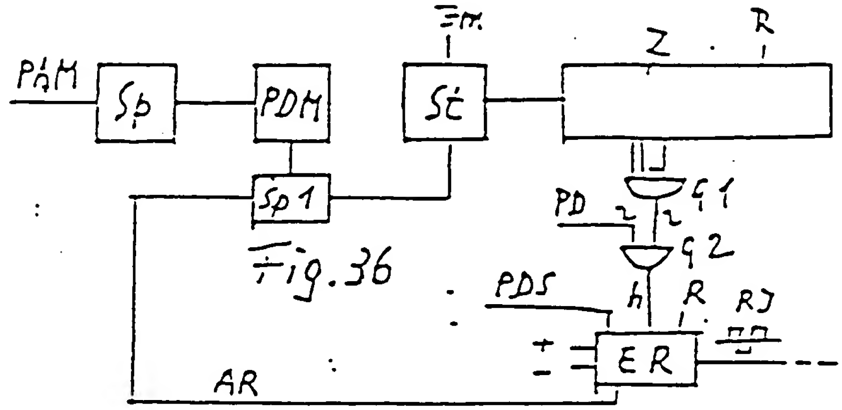


Fig. 36

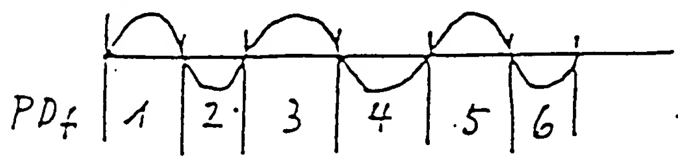


Fig. 37

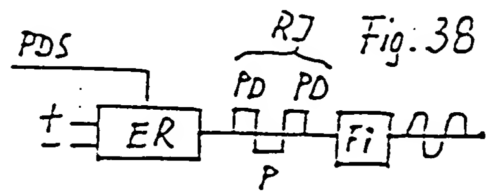


Fig. 38

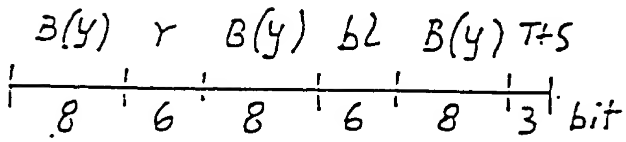


Fig. 65

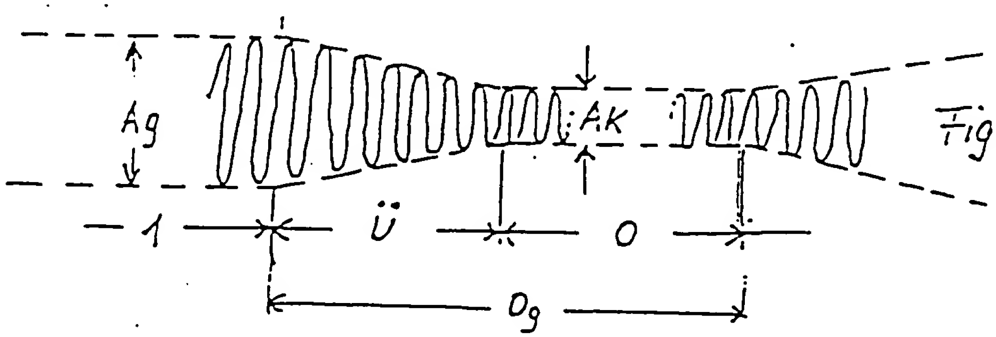


Fig. 66

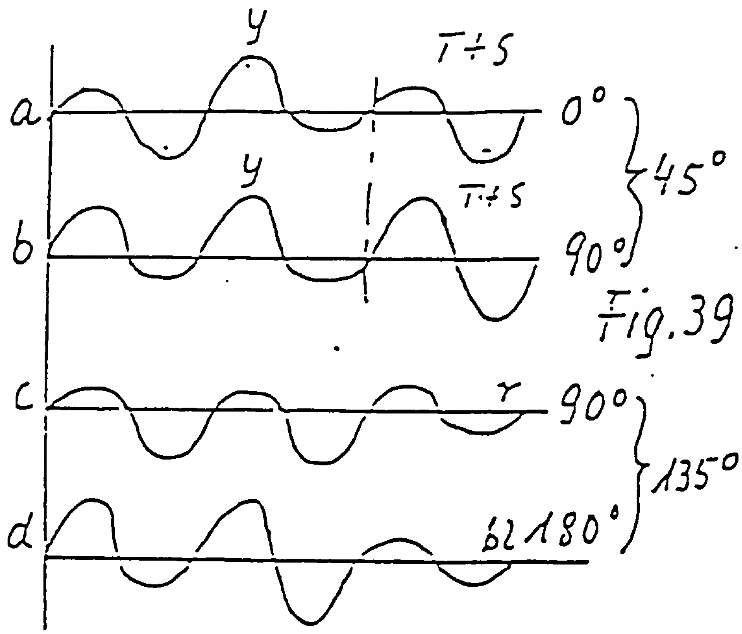
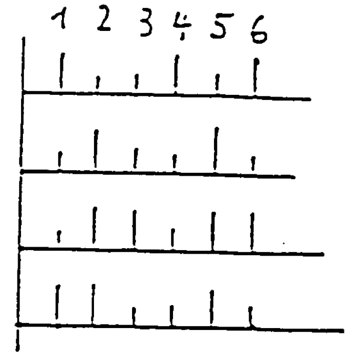


Fig. 39

Fig. 40



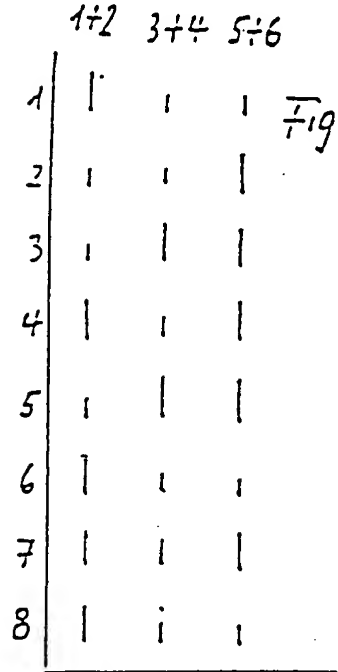


Fig. 41

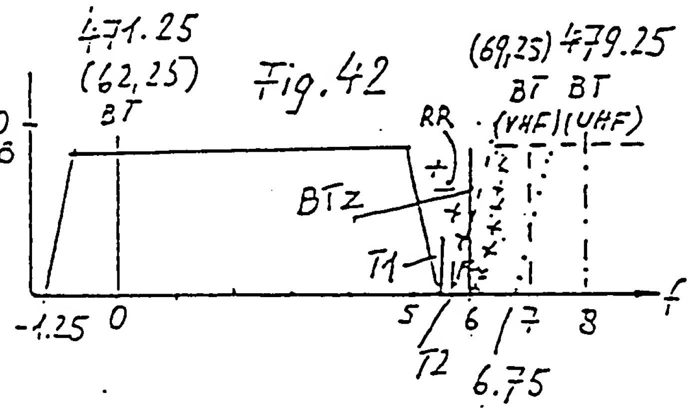
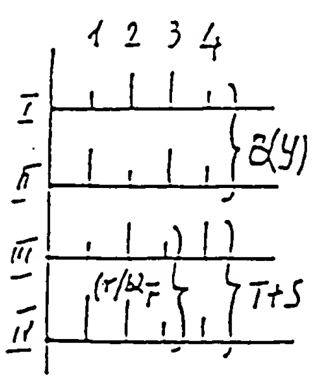


Fig. 42

Fig. 43



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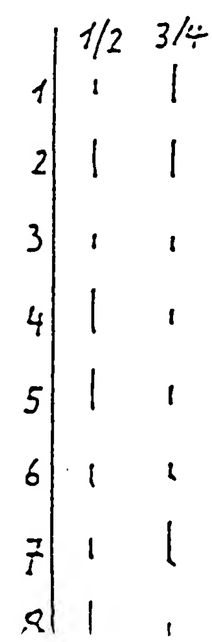

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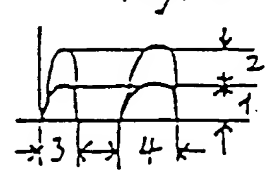
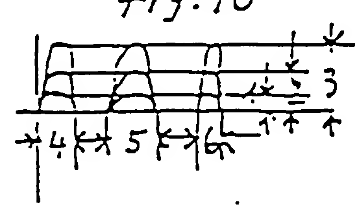


Fig. 46



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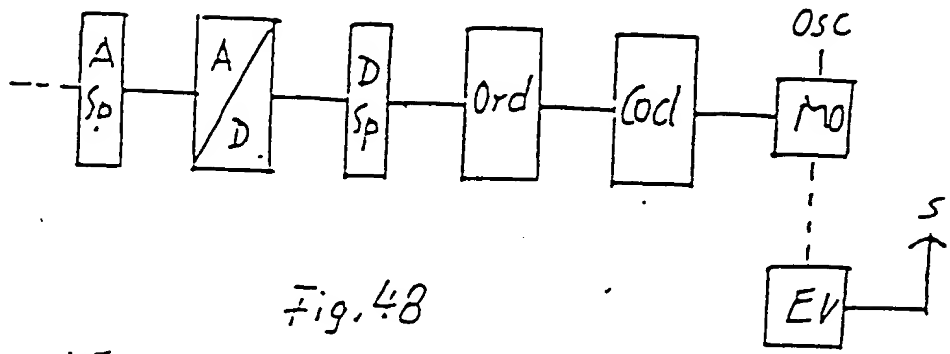
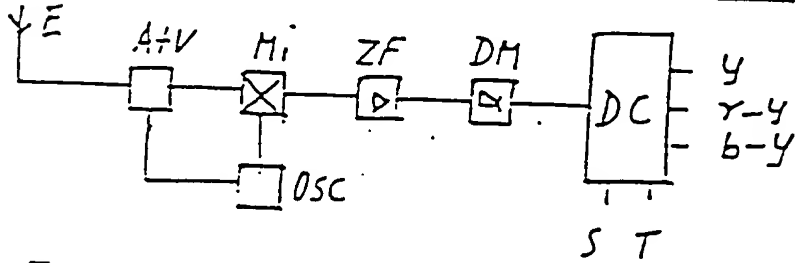


Fig. 48



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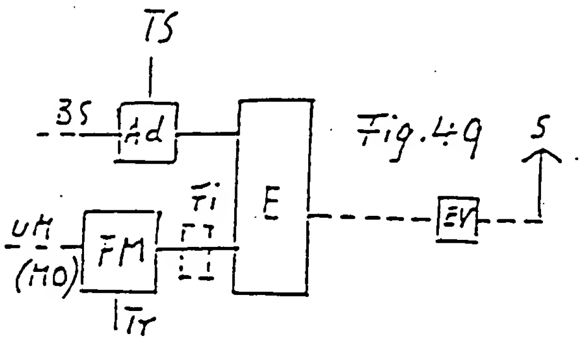


Fig. 50

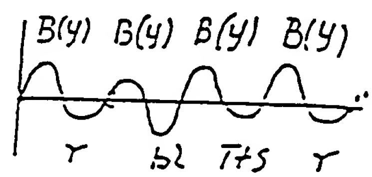


Fig. 51

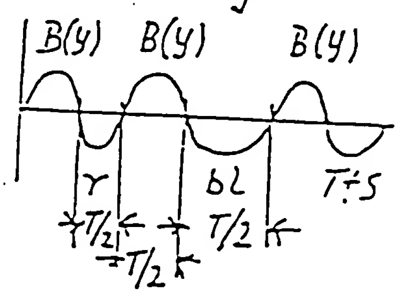
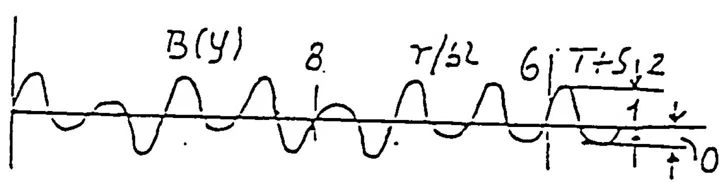


Fig. 53



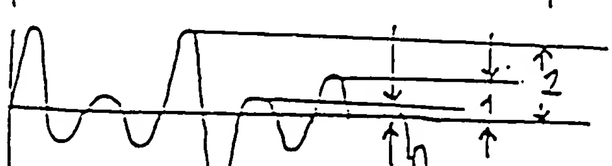
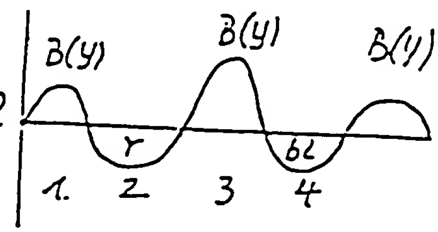


Fig. 54

Fig. 52



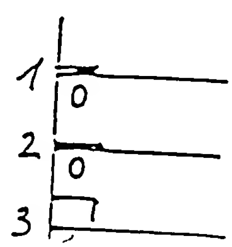


Fig. 55

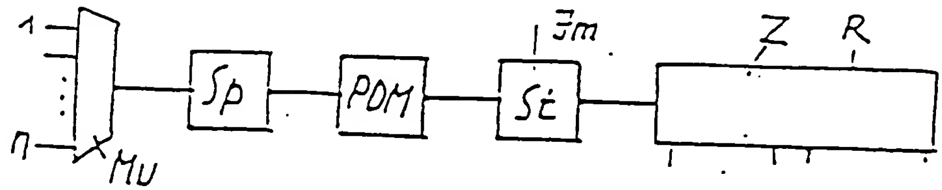
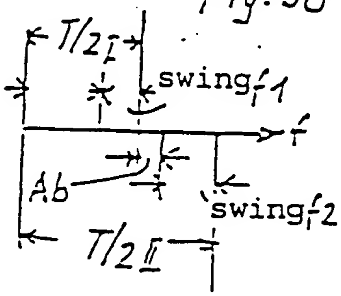
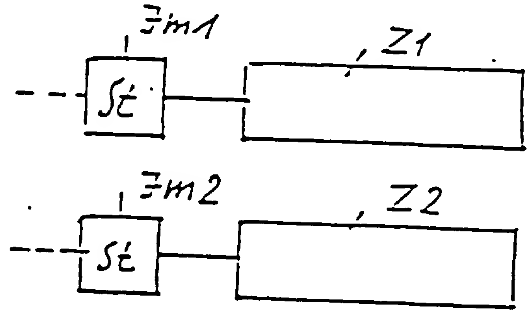


Fig. 56

Fig. 58





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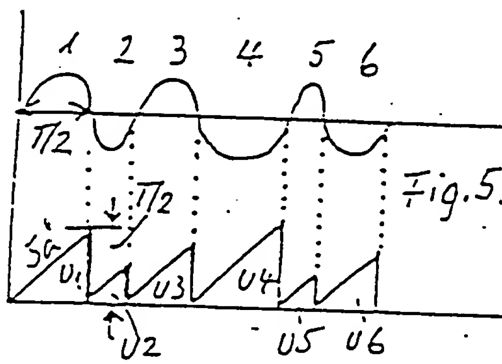


Fig. 59

Fig. 60

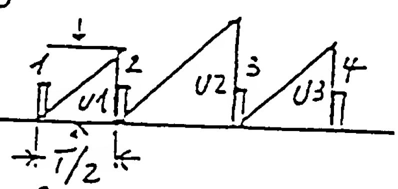


Fig. 61

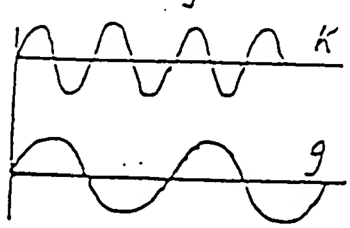


Fig. 62

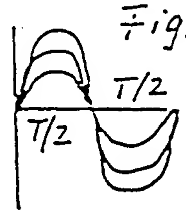
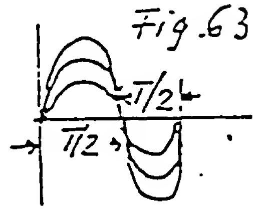


Fig. 63



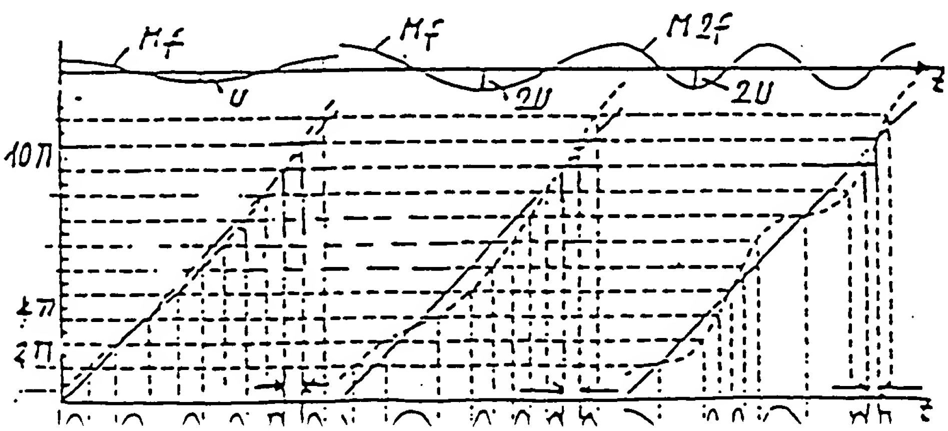


Fig. 64